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THE INTERNATIONAL EXHIBITION OF 1876.

THE HOTCHKISS CANNON REVOLVER.

In the Ordnance Department of the Government Building at the Centennial Exposition is exhibited the new Hotchkiss cannon revolver, a weapon which bears about the same relation to the rifled field cannon as does the mitrailleuse to the small arm. Apart from its being of interest as a remarkable advance in artillery construction, it possesses a timely importance, inasmuch as the gun has lately been the object of trials made under United States army auspices, at Sandy Hook, N. J., which have resulted in the purchasing of sample batteries by our Government. The cannon composing these batteries will be subjected to further tests, which, if satisfactory, will probably lead to the adoption of the invention in the army and navy.

An excellent representation of the cannon revolver is given in Fig. 1. It is an assemblage of five Whitworth steel rifled cannon of 1.44 inch calibre, which, discharging in succession as they rotate, are capable (as the records of official tests made abroad indicate) of firing a maximum of 80 shells per minute, and of projecting them to a distance of over 3¼ miles with accuracy. Each missile, as shown in Fig. 2, which is reproduced from photographs of the exploded shells, is capable of bursting into an average of 20 pieces. The gun gives, therefore, 80 dangerous points, 80 explosions, and 1600 fragments. It is hardly necessary to point out the terrible effects of such a hurricane of metal.

The system is composed of two distinct portions—namely, the barrels with their disks and shaft, and the frame and breech containing the mechanism. The barrel shaft penetrates the breech to receive the rotary motion from the driving gear.

A peculiar feature in this gun consists in the barrels remaining still during the discharge, so that there is no movement of any kind to impede the accuracy of fire. This stop or lost motion is obtained by the shape of the driving worm, which is located on a horizontal shaft which passes through the breech block, and on the right-hand extremity of which is the crank by which the mechanism is set in motion. The worm is so constructed that the inclined driving thread only covers half its circumference, the other half of the thread being straight. The effect of this is, that the barrels only revolve during half a revolution of the worm, and stand still during the other half revolution. The combination of the mechanism is so arranged that the loading, firing, and extracting take place during this pause.

On the left-hand end of the horizontal shaft, and within the breech, is a crank which moves in a slot in, and so reciprocates, a horizontal rack. The teeth of this rack are turned upward and engage with a cog-wheel, which wheel in turn operates another rack above it: so that as one rack moves forward the other moves backward, and *vice versa*. The under rack forms the extractor, the upper one moves a piston which drives the cartridges into the barrels, the cartridge being placed before the piston, in the trough in which it moves; and during the time the barrels are motionless it is introduced into the one standing before the trough.

The operation of the mechanism may be described as follows, supposing the crank to be in continual motion: A cartridge is placed in the introduction trough, the piston pushes it into the barrel, then the barrels begin to revolve, and the head of the cartridge is forced against an inclined plane on the breech block, which pushes it fully home. Then the cartridge is carried on till it arrives before the spring firing-pin which penetrates the solid part of the breech, and which has in the meantime been retracted by the action of a cam on the horizontal crank shaft. Then, as soon as the cartridge has arrived into this position, the barrels cease to revolve, and the primer of the cartridge is struck by the firing-pin and discharged; then the revolution of the barrels begins again, and the fired cartridge shell is carried on until it comes to the extractor; this in the meantime has arrived up to the barrels and the cartridge head rolls into it. As soon as the head is laid hold of by the extractor, the barrels again cease to revolve, and during this period the cartridge shell is withdrawn and dropped to the ground. As during every stoppage of the barrels the gun is supplied with a new cartridge, and the firing and extraction are also performed, during this time a continuous but slow fire is kept up. By supplying the gun in this manner with single cartridges, about thirty rounds per minute may be fired.

Should *rapid* firing be required, the gun is then supplied, not with single cartridges, but with "feed-cases," containing groups of ten cartridges each, and in this manner from sixty to eighty rounds per minute can be fired, with only three men to work the gun—namely, one man to train the gun and revolve the crank; one man to place the "feed-cases" containing the cartridges into the "feed-trough;" and a third man at the ammunition chest, to charge the "feed-cases," and to hand them to the charger. Attached to the frame is a turn-table, which connects the cannon to the "trunnion saddle," arranged in such manner that without displacing the carriage a certain amount of lateral motion as well as of elevation may be given to the gun. Thus the gun is made to sweep horizontally along a line, by adjustment, between each single shot, or during rapid discharge.

THE INTERNATIONAL EXHIBITION OF 1876.—Fig. 1. THE HOTCHKISS CANNON REVOLVER.

Fig. 2.—BURSTED PERCUSSION SHELLS FROM CANNON REVOLVER.

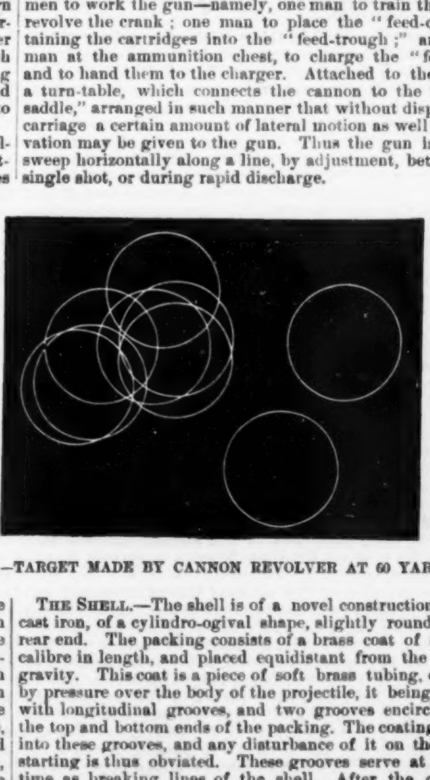


Fig. 3.—TARGET MADE BY CANNON REVOLVER AT 60 YARDS.

The Shell.—The shell is of a novel construction; it is of cast iron, of a cylindro-ogival shape, slightly rounded at the rear end. The packing consists of a brass coat of about one calibre in length, and placed equidistant from the centre of gravity. This coat is a piece of soft brass tubing, contracted by pressure over the body of the projectile, it being provided with longitudinal grooves, and two grooves encircling it at the top and bottom ends of the packing. The coating is forced into these grooves, and any disturbance of it on the body at starting is thus obviated. These grooves serve at the same time as breaking lines of the shell. After the coating is attached to the projectile, some small saw-tooth-like grooves

are cut into it, to reduce the strain while being forced through the rifling of the barrel. The coating of the projectile is conical at its front part, corresponding with the cone in the projectile chamber, so that it is exactly centred in the bore as soon as the forward movement commences. Its rear end is cylindrical to within about one third of its length. The shell is turned smooth all over, and is made with great care and exactness, with only a very small deviation in dimension. The fuse employed is that known as the Hotchkiss percussion fuse, used in large quantities during the war.

THE CARTRIDGE CASE.—The cartridge case is also new, and consists of a spirally rolled tube of sheet brass, strengthened at the head with an inside and an outside cup. The head is punched out of sheet iron, and is fastened to the cups with three rivets. The primer consists of a case holding the anvil, and is closed at the bottom end by the cap containing fulminate; it is fitted into a hole which penetrates the head and both cups, and it projects through into the inside of the cartridge case.

To check the recoil of the gun, a brake of the following construction is used: Each axle arm has a screw cut on its extremity; this carries a nut, forming a conical cap, partly enveloping the inside of the wheel nave, which is likewise conical, to fit the inside of the cap; this has a short crank, by which it can be revolved on the axle. When screwed up, this cap grips the cone of the nave of the wheel, and the tighter the cap is screwed up so the wheel turns with the more difficulty on its axis, until it gets immovably locked on the axle by the friction of the cones. When the cap is unscrewed, it is disengaged from the wheel, which then can turn freely on the axle. The screws on the ends of the axle arms have right and left handed threads, so that the caps become tightened by the effect of the recoil. This brake is used at the same time as an ordinary travelling brake, and it can be applied without the carriage being stopped, as is necessary with the shoe-brake commonly used on gun carriages.

The accuracy of fire of which the gun is capable is indicated by Fig. 3, which is a tracing reduced exactly one half from a target made at sixty yards range. The nine rounds were fired in a volley, and seven projectiles, as will be seen, struck on the same spot.

The inventor of the weapon is Mr. B. B. Hotchkiss, of New York City.

THE INTERNATIONAL EXHIBITION OF 1876.

THE BALL PUZZLE.

No. 27.

THE curious phenomenon indicated above, and mentioned in No. 37 of this paper, has attracted considerable attention among professional men, and excites the wonder of large crowds at the Centennial. It is exhibited in connection with the Westinghouse Air Brake, at Column D, 68, Machinery Hall. The air-compressing apparatus of the above company maintains about 70 lbs. pressure of air in their reservoir, and the surplus is permitted to escape through a nozzle having a bore of about ⅛", which is set at an inclination of about 30° from the vertical. In the jet of air proceeding from this nozzle is placed a ball, which remains suspended therein at a distance above the nozzle depending upon the diameter and weight of the ball and the velocity of the issuing air; the whole as shown in Fig. 1. Various balls are used: as a solid one of glass, of 1½" diameter; two of wood, solid, 3" and 3¾" diameter; and two hollow rubber balls of 3" and 5" diameter.

The phenomenon is more curiously illustrated by placing the small glass ball first in the jet, and in the stream of air above it the larger rubber one, sufficient velocity remaining in the jet to support the latter as well as the former; their weights, as compared to their volumes, permitting of their support in the two different positions. Either one of them alone would occupy a similar place with the same pressure in the reservoir.

FIG. 1.

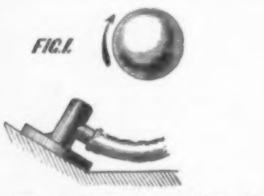
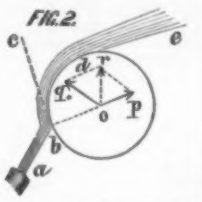


FIG. 2.



The impression created by this exhibition is quite striking, and most observers are willing to admit at once that, if the jet were vertical, there would be nothing at all curious in it; but, when issuing at such a very considerable inclination, it is generally agreed there is something almost magical about the suspension of the ball.

Generally the ball will not only remain suspended as shown in the figure, but will rotate rapidly in the direction indicated by the arrow. Where the ball has a heavy side, it may be made to remain quiescent if the preponderance is sufficient to overcome the friction of the air on the upper side of the ball, that being the cause of the ball's rotation. The hollow rubber balls, from their elasticity, are made to assume the spheroidal form by the shortening of the axis of rotation; but this axis does not preserve an invariable position from several causes: it appears to be impracticable, under the conditions had, to prevent oscillation of the ball, and, of course, with every lateral oscillation the centre of the jet will impinge upon a different part of the surface, tending to rotate it in a slightly different direction; also a change of form from the true sphere is produced by the different conditions as to pressure upon the surface, which, in the elastic balls, tends to produce a shorter diameter in a direction not precisely that produced by its rapid rotation. These perturbations, together with the well-known tendency of any rotating body to perform its rotations about its shortest axis, produce some very curious changes in the form of the elastic balls, and the position of their axes of rotation.

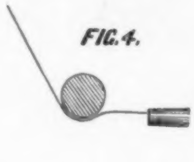
At one of the regular meetings of the Technical Society of Philadelphia, some discussion of this phenomenon was had, and at another meeting Mr. Hugo Bilgram suggested the following explanation:

"The investigation of the cause of this phenomenon was commenced with an examination of the course the air current takes in striking the ball. This investigation revealed the fact that the current *a b* (Fig. 2), instead of leaving the ball in the line *b c*, as might be expected, follows the curvature of the ball along the line *b d*, and at length leaves the ball in the line *d e*. A light ball, when placed in the jet, is struck nearly centrally (see Fig. 3); the current envelops the whole ball and unites again, leaving the ball in the line *d e*, appearing as though the current was passing through the ball. It can, however, easily be found that the upper branch of the current is stronger than the lower one.

"By a series of subsequent experiments, it was found that any current of air striking a convex surface has the tendency to follow that surface. One of these experiments is as follows: Attach to one end of a small tube, about ⅛" to ¼" diameter, and 4" to 6" long (which may be made by rolling up a piece of writing-paper), a piece of thread or yarn, about 4" to 5" long. Blow through the other end of this tube, and direct the current against an object with a convex surface. The thread, following the current, will indicate a deflection as indicated by Fig. 4.

FIG. 3.

FIG. 4.



"After demonstrating this fact, the next step was to find its cause. It is well known that any current tends to carry along with it the surrounding particles of air; hence, the supposed current *b c* (Fig. 2), being freely supplied with air from the left side only, will create a rarefaction of air in the angle *c b d*. It is thus exposed to a one sided pressure, and will therefore be deflected, as mentioned, and follow the curvature of the surface until it meets a counter current sufficiently strong to prevent a further rarefaction. If this view can be substantiated, it is plain that two external forces are acting upon the ball. One, the impact of the air-current at *b*, transmitted at right angles to the surface, acts radial, and can be represented by the line *o p*. The other force, *o q*, is occasionally by the surplus pressure of the atmosphere on the lower side of the ball over that of the rarefied zone under the curved current, and combined with *o p* it forms the vertical resultant *o r*, by which the weight of the ball is sustained.

"The rarefaction of air under the deflecting current can be proved by the following experiments:

"Cut a small hole, say ½" square, in a card-board; fasten over this hole a cover of the same material, by means of a strip of thin paper and mucilage, to form a valve, and bend both the card and the valve into a cylindrical form. If now a current of air is directed against the card, as shown in Fig. 5, the valve will open wide, showing the pressure under it to be greater than that above it.

"Or, take a strip of ordinary paper, about 1" to 2" wide, lay it over a cylindrical surface and blow against it in a nearly tangential direction. The end of the strip will then rise as shown in Fig. 6.

"Quite a number of other experiments might be mentioned, showing the same facts.

"The rotation of the ball is produced by the friction of the air-current passing over the ball, and is therefore a secondary result.

"The phenomenon of deflection of a current when striking a convex surface can be brought to bear on geographical and meteorological facts. The Gulf Stream follows the curved shore of the United States, for the identical reason that the aerial current follows the shape of a cylinder or a globe, and takes a course which otherwise it would not take. When a current of the higher strata of the atmosphere strikes the peak of a mountain it will be deflected, follow the sides of the mountain, and will sweep the valley."

FIG. 5.

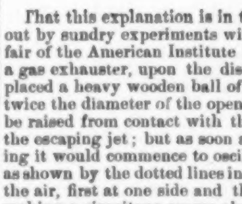
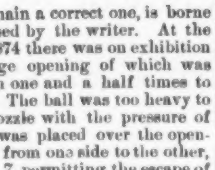


FIG. 6.



That this explanation is in the main a correct one, is borne out by sundry experiments witnessed by the writer. At the fair of the American Institute in 1874 there was on exhibition a gas exhauster, upon the discharge opening of which was placed a heavy wooden ball of from one and a half times to twice the diameter of the opening. The ball was too heavy to be raised from contact with the nozzle with the pressure of the escaping jet; but as soon as it was placed over the opening it would commence to oscillate from one side to the other, as shown by the dotted lines in Fig. 7, permitting the escape of the air, first at one side and then at another, and sometimes making a circuitous course about the opening, bearing always at some point upon its edge, and making altogether a very curious exhibition. If the ball was removed to one side by the hand, so far as to leave one side of it just projecting over the opening or in contact with the extreme boundary of the jet of air, as shown by the dotted circle to the extreme right or left, Fig. 7, it would be quite forcibly drawn toward the opening, making an excursion to nearly the same distance upon the other side, and finally oscillating in continually diminishing distances until it arrived at the particular amplitude which would comport with the synchronism of the ball and the escape of the air. This last experiment shows quite conclusively that, as soon as the ball is brought into the slightest contact with the jet, a portion of the atmospheric pressure is removed from that side of it upon which the jet impinges, which is more than sufficient to compensate for the repelling force of the jet upon that part of the surface of the ball where it first strikes it; and as in this case the ball may move upon the horizontal smooth surface of the flange surrounding the opening with great facility, it is forced toward the opening by a very slight preponderance of atmospheric pressure upon the other side. In its excursions to and fro across the opening there are at times, of course, portions of the air passing by either side, or all round it, and if the ball were light enough it would be raised from its plate and suspended precisely as in the inclined jet, but the ball being too heavy it can only permit of the escape of the air by oscillating from side to side; and, as soon as a preponderance of the jet obtains upon one side the pressure of the air is thereby partially removed from that side, and thus the ball is forced back again, and the oscillations continue.

Another curious experiment illustrating this principle is shown in Fig. 8. If a jet of air be made to issue from an opening surrounded by a broad flat circular flange A A, and a flat disk B (having stems or guides extending from its lower side into the opening to prevent lateral motion) be placed as shown over the nozzle, it cannot be blown away, but will rise to a distance, depending upon the weight and diameter of the disk and the velocity of the air, and will there remain suspended in apparent opposition to the direct force of the blast. If there are no flanges, A A, the disk will be blown off at once.

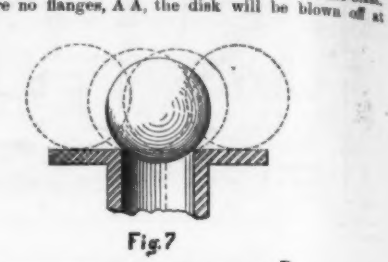


Fig. 7

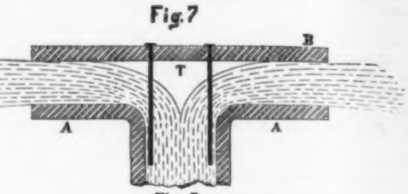


Fig. 8

In this experiment, as soon as the air strikes the under side of the disk, and before the inertia of the disk is overcome, the current is spread out and deflected downward upon the flange, and at the same time, at the first moment of the rising of the disk, the external air must begin to move inward between the two disks, until the issuing current fills the space; and as this space for a very small upward motion of the disk is much greater than is required for the escape of the amount of air corresponding to the opening made at the nozzle by such rise, the inward rush of air around the circumference must be considerable, until the aggregate opening around the circumference becomes sufficient to permit the escape of the given quantity of air at a pressure something greater than that of the atmosphere. In this way the first movement of the disk upward results in causing the jet of air to become spread out, and to follow the surface of the lower flange, in doing which the pressure is removed from between the passing air and the lower flange, and thus from the under side of the disk on a given part of its central area, and the pressure of the air above the disk prevents its rising higher. Of course the pressure upon the under side of the disk at the immediate periphery must be greater than that of the atmosphere, or the air from the jet could not issue from between the two, and the partial vacuum must obtain under the more central parts. It will be readily seen, in this case, that when the exact conditions of suspension are reached no air can enter at or between the periphery of the disks, as sufficient pressure must exist at this point to permit of the escape of the air; otherwise, as in the case of the absence of the upper disk, the air would rush in upon the lower surface to supply the partial vacuum produced around the lower parts of the issuing jet, after the manner of the blast jet in a chimney.

The formation of the currents of air in this experiment would probably be somewhat as shown in section in Fig. 8; and the partial vacuum is formed more or less in a triangular space, T, as indicated, and as is proved by the fact that, with holes in the central part of the disk permitting the descent of the atmosphere to fill the partial vacuum, the disk is instantly blown away.

Another experiment, which is quite conclusive in this direction, is shown in Fig. 9. Take a strip of ordinary writing paper, about 2" wide; hold one end between the third and fourth fingers and the other between the thumb and index finger in such a way that a semicircular arch of the paper shall extend from one pair of fingers to the other. Then direct a current of air from the stem of a tobacco pipe or other small tube against the thumb end in such a way that the direct pressure of the issuing jet shall react against the index finger, as shown. The result will be that the paper will assume the form indicated by the dotted line, the paper being forced into the partial vacuum just as the ball is in Fig. 7.

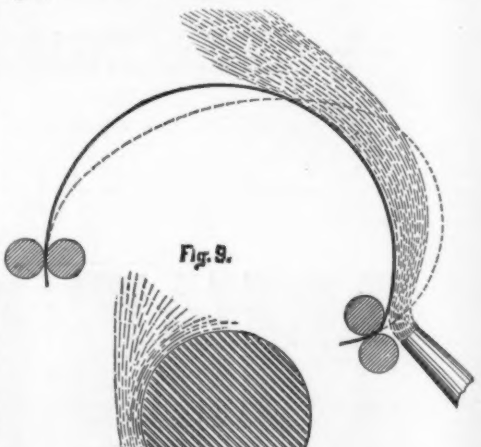


Fig. 9.

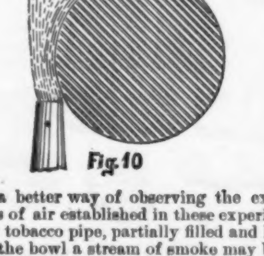


Fig. 10

Perhaps a better way of observing the exact behavior of the currents of air established in these experiments is to take an ordinary tobacco pipe, partially filled and lighted; then by blowing in the bowl a stream of smoke may be made to issue quite forcibly from the mouthpiece. If this stream be directed as in the experiments mentioned, the course taken by the air currents may be very readily seen. For instance, when directed against a cylindrical surface, as in Fig. 9, the smoke, or a large part of it, will be seen to follow the surface of the cylinder for a considerable fraction of its circumference, bending a large part of the stream considerably out of what would be its course in the open air unobstructed. In this way, too, it is easily seen that where a jet is made to impinge upon a cylindrical or spherical surface so nearly in the direction of a radius as to divide the jet, a considerable portion of the air will follow quite around the curved surface on both sides, become rejoined upon the opposite side

and pass away in the original direction as an apparent continuation of the jet through the ball or cylinder; only a portion, however, is thus bent out of its course, and in this respect Figs. 2 and 3 do not quite fairly represent the result.

If the above is a correct interpretation of the phenomenon indicated, it is plain that it is no more singular that a ball should be suspended in an inclined than in a vertical jet of air or water; indeed, it is a self-evident proposition that a ball in the vertical jet of a fountain, as often seen, is not supported by simply lying in the crest or spreading portion of the stream, as many imagine or contend; for it is very plain that the slightest oscillation would cause a preponderance of the jet upon one side of it and throw it off, and the equilibrium would be of so unstable a character in such a case as to preclude a ball ever being supported at all, or even reaching the crest of the jet. We know, however, that in such instances a ball will continually dance from side to side on the crest, making very considerable excursions from side to side without falling; and when at times it does overleap the extreme position at which the jet has the power to draw it back, it will often be seen to be caught while falling, and before reaching the basket at the bottom, by the side of the ascending jet, and again elevated to the crest—a thing manifestly impossible if it were merely riding upon the water when supported. Moreover, it is well known that it is not at all necessary that the water jet shall be vertical in order to support a ball in that way.

It appears to be plain, then, that with a jet of air or liquid issuing from an orifice with considerable velocity, the exterior portions by friction upon the surrounding air impart motion to the latter, and that, when unobstructed, currents are thus established to supply the place of the air moved away, something as indicated by the arrows on the left in Fig. 10. Upon the interposition of a cylindrical or spherical body, as indicated on the right, the friction of the jet removes the air from the acute angle *a* in the same way, and as it can not be supplied because of the interposition of the ball, a partial vacuum is there established, which in the case of the vertical jet simply results in the ball being forced into the jet by the atmospheric pressure, when it becomes driven upward by the force of the jet, and in the case of the inclined jet supporting the ball by the pressure of the air alone where the inclination or weight of the ball is such that no part of the jet passes upon its lower side. In the case of the inclined jet, no doubt the rapid rotation of the ball caused by the friction of the jet upon it aids in producing the partial vacuum in the angle *a*, by removing the air from it in the same way as the jet itself does; and therefore it is probable that a ball whose geometrical centre coincides with its centre of gravity, and which can therefore be caused to rotate, will be suspended at a higher point in a given jet than one that has a heavy side sufficient to prevent its rotation. If the jet be horizontal, a ball is not supported, for the reason that gravity does not prevent its being carried along horizontally until out of the influence of the jet.

J. T. H.

BRADLEY'S HAMMER AT THE EXHIBITION.

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THE helve of this hammer hangs loosely upon the spindle, to which is attached an oscillating frame furnished with four india-rubber spring cushions, through which motion is imparted to the hammer. The length of stroke is regulated by an adjustable eccentric; the foot treadle for setting the machine in motion passes entirely round the base of the tool, so that the smith can place his foot upon it in whatever position he may be standing while using the hammer. The tension of the rubber cushions can be regulated by set screws in the upper and lower arms of the oscillator. It is claimed for this hammer that the blow given by it is the nearest approach to that given by the smith's arm that has yet been attained by mechanical ingenuity.

THE EMPIRE TRANSPORTATION COMPANY AT THE EXHIBITION.

THE Empire Transportation Company, a large and important association in the United States, is represented at the Philadelphia Exhibition by a very interesting collection in a separate pavilion, 45 ft. long and 35 ft. wide, with a small wing on each side. Within, a counter extends all round the building, on which are displayed the objects exhibited. They consist of well-executed models of cars representing those used by the company, of lake steamers, and grain elevators, and a large number of details connected with the handling and transportation of merchandise. One wing of the pavilion contains a large model of petroleum oil machinery, and the various processes of sinking shafts, erecting derricks, pumping and transporting oil are there exhibited. The opposite wing contains an extension of this class. They comprise an oil-pumping station, railway sidings, and cars, showing the mode of filling the latter, and near by is a model of an underground receiving tank, and the terminal station arrangements for receiving and handling the oil. Around the walls are ranged maps, plans, and sections showing the extent of the company's lines, its modes of working, and the localities and formation of the Pennsylvania oil region. The State of Pennsylvania granted a charter to the Empire Transportation Company early in 1865, and shortly after it commenced operations. Its object was to increase the facilities of transport between inland points west of the Philadelphia and Erie Railroad and the Atlantic seaboard. To effect this satisfactorily, running powers over no less than ten different lines were required, and the organization was all the more useful, because although these various lines had strong interests in common, they were at the same time invested with opposing interests which had created differences to the great damage of the railways themselves, and to the loss and inconvenience of the public. These differences had in fact grown to such an extent, that transport of freight from inland points over the route formed by the various companies was almost impossible. Each railway worked independently, regardless of those connected with it. Contracts entered into between the public and one railway were disregarded by the controller of an adjacent line, which charged its own rates, chose its own time of delivery, ignored the responsibility of damage, and permitted delays in transfer sometimes amounting to weeks. Under these conditions consignees could seldom obtain redress for damage suffered or delays incurred. It was over these routes influenced by such conflicting interests that the Empire Transportation Company commenced in 1865 to run their own stock, acting as common carriers, and using the various railways for their purpose. Before their time a similar organization, under the title of the Union Line, had been working, with much success, over some of the roads of the Pennsylvania Railroad Company. In 1873, the latter company purchased the rights of the Union Line, and controlled its operations themselves.

In addition to acting as transporters of merchandise, the Empire Company, at an early period of its existence, purchased its first oil-pipe line, at that time a speculative undertaking which has since proved very successful. Later a still more important extension was made. When the Philadelphia and Erie Railroad had completed its connection with the harbor of Erie, and thus joined with the navigation of the inland lakes, it was found that no profitable trade could be obtained, because Buffalo and Oswego were the recognized and established ports, and business converged in these two points. To enter into successful competition new and extended enterprise was necessary, and the Empire Transportation Company undertook the work. They built a new line of lake steamers, erected elevators, and constructed wharves at Erie; offered inducements to shippers in lower freights, and larger guarantees of responsibility, and by this means gradually created a large and profitable trade for the new route.

Thus gradually developed, the Empire Transportation Company possesses now 4500 cars running over the various railways. On the lakes it has twenty steamers, the largest of 1500 tons capacity, and the total carrying powers of which are 19,600 tons per trip, equivalent to 10,000,000 bushels of wheat each season. It has wharves and depôts in New York, New Jersey, Philadelphia, and Baltimore, and grain elevators in Philadelphia, Erie, and Baltimore. The elevators at Erie are 96 ft. long and 72 ft. wide, of timber, inclosed in brick walls, and with a slate roof. The buildings are 109 ft. high, with towers 124 ft. high. The structures rest upon piles inclosed within timber cribs. One of the elevators contains 47 bins, holding collectively 250,000 bushels, and the rate of transhipment is about 100,000 bushels per twenty-four hours. The mode of working is as follows: when a loaded grain ship comes alongside the elevator, a movable jib, on which runs a belt 157 ft. long and 17 in. wide, and having on it 154 buckets, each holding a quart, is lowered into the hold of the vessel; motion is then imparted to the belt, which raises the grain to the top of the tower, and discharges it into the hopper of a weighing machine, which measures off each 100 bushels; after this has been done the grain falls into a receiver below the floor level of the building. In this receiver is another belt, similar to that described, and by this it is raised into a large distributing chamber at the top of the house. By means of spouts, the grain is led from the chamber into the various bins, and is ready for transhipment into the cars. Underneath the bins on the ground level are laid two railroad tracks, and on each is a weighing table. When the cars are loaded, they are run upon the table and weighed, the operation being repeated after they are full.

The second elevator referred to is similar to the first, except that it contains 31 bins, and has a storage capacity of 100,000 bushels.

Regarding the oil-region branch of the undertaking, there are three sections of oil-pipe lines owned by the company. The first of these is known as the Union Line, having 350 miles of pipe, and a pumping capacity of 800,000 gallons each 24 hours. The second is the Titusville line, 45 miles long, and pumping 126,000 gallons per 24 hours. The third is the Olean line, 30 miles in length, and with a capacity of 55,000 gallons in a similar period.

The pipe employed for this purpose is generally of wrought iron, lap welded, and 2 in. in diameter; the lengths are joined together with screw unions. The pipe is laid for the most part on the surface of the ground, except where it crosses roads, streams, or other places where protection is required. The main lines are laid as direct as possible from the centres of supply to the nearest railway unloading stage. Here they discharge into iron tanks, varying in capacity from 5000 to 20,000 barrels, and placed so high that their contents may gravitate into the oil cars. At various points along the line pumping stations are placed. Besides the necessary pumps and engines, these stations comprise two tanks, each holding from 500 to 2000 barrels, a telegraph and clerks' offices, etc. To these stations converge numerous lines of pipes leading from the different wells in the locality, these wells discharging into storage tanks from which the pipes are laid. Before drawing from these tanks, their contents are carefully gauged and recorded, and this operation is repeated when the pumps from the main line station cease to draw from them. The difference in inches is then credited by the Transportation Company to the owner of the well, who receives a certificate, which is a negotiable document payable at sight by the company. On reaching the pumping station the petroleum from the various wells is mingled in one common stock. It may be mentioned here that the lines of pipe are laid over very irregular ground, in one instance there is an elevation of 968 ft. to be overcome by the pumps in a distance of 14 miles. Some idea of the large amount of work done in this branch of the company's business may be gathered from the fact that from the period when they first acquired possession of the oil-pipe lines to the 31st of March, 1876, there passed into the main reservoir a total of 375,810,500 gallons of crude petroleum.

The cars into which the oil is loaded are of sheet iron, cylindrical, and closed up in all parts except at the manhole through which it is loaded. The capacity is about 3600 gallons. The method of loading is as follows: From the elevated tanks a main is led to a raised platform, built alongside the siding to which the receivers are brought to be loaded. At intervals, corresponding to the length of a car or receiver, the unions are attached to the main, and these carry movable branches, the ends of which can be led into the opening in the manhole of the receiver. A cock is placed at each union to control the flow of oil.

The principal oil depôt of the company is at Communipaw, New Jersey, where the cars discharge, and where large iron tanks are constructed for the reception of the petroleum. From this point to the refineries in New York, the oil is carried in bulk in tank barges holding from 1000 to 1500 barrels.

The following figures will convey an idea of the growth of the Empire Transportation Company since it commenced its operations. During the first year its traffic movement amounted to 37,021,500 tons carried over a mile, and during 1875 it had increased to 814,639,468 tons moved one mile.—*Engineering.*

BONITA STEAM YACHT AT THE CENTENNIAL.

THE steam-yacht Bonita, on the Schuylkill, is an interesting object to those who have a taste for nautical matters. She is fitted with the propeller-steering apparatus of F. G. Fowler, of Bridgeport, Conn. Her hull and woodwork were constructed by Mr. Frederick Wood, also of Bridgeport. Her length, over all, is 50 feet, beam 7½ feet, draught of water 2¼ feet. She is constructed with a forward cabin, 10 feet long, and has a cock-pit aft of the same dimensions, the intervening space being occupied by the boiler, donkey-pump, etc. Her engine is located aft, and is a simple horizontal, high-pressure engine, with a 9-inch cylinder, and 9-inch stroke, cutting off at 7 inches; the ports being on the under side of the cylinder, and always admitting the passage of condensed water through them. The bed-plate is tubular, and is secured to three bulkheads, which are fastened to the keel, stern-post, and planking, thus rendering the whole firm and rigid. The wheel is 36 inches in diameter, is 14 inches deep, and has an effective pitch of 4 feet 8 inches, and a maximum velocity of 350 revolutions a minute. The Bonita is a very fast boat, and has astonished the Schuylkill boatmen, especially in backing past their passenger steamers which were going ahead. The *New York Times* says that Mr. Fowler offers to try the Bonita in any series of competitive trials with any boat in the world, length allowance to be made, where there is a difference of dimensions. He proposes seven different trials. They are, first, a straight course ahead, to demonstrate efficiency when steaming ahead. Second, a straight course astern, to demonstrate efficiency in backing. Third, a curvilinear course ahead, to test steering power in connection with steaming ahead, such as is required in following crooked channels, turning in narrow channels, avoiding collisions, naval manœuvres, etc. Fourth, a curvilinear course astern, to test steering power when backing. Fifth, turning a boat on her centre by steam, or shifting her end for end, such as is required in "winding" a boat at her dock, or manœuvring in naval actions. Sixth, a trial in shoal water, to test the efficiency of propellers of light draught. Seventh and last, a trial in rough water, to demonstrate the satisfactory working of propellers when partly submerged, and to test their efficiency in bringing a vessel out of the trough of the sea, head on.

The steering propeller is submerged at the stern of the boat and rotates in an upright shaft, the lower end of which is supported by an extension of the keel. Motion is communicated to this shaft by a horizontal engine, which is coupled to it directly, without the intervention of gearing. The propeller consists of horizontal arms, keyed to the shaft, and supporting vertical blades at their extremities. These blades are hung on pivots, and have an oscillating motion of about thirty degrees. The motion is produced by an eccentric with which each blade is connected, the adjustment being such that the blades are given two sculling strokes for each revolution, so as to pull on the forward half and to push on the after half of their circuit. As the blades revolve they describe the position of the body of a fish while swimming, and are said by scientific men to produce the same mechanical effects. The propelling force is exerted in the direction of the short radius of the eccentric, and as this is connected by a sleeve and suitable gearing to the helm or steering wheel, the steersman is enabled to turn the eccentric and thereby cast the propelling force to any point of the compass. For this reason there is no necessity for reversing the engine in backing. Neither is there any necessity for reversing gear or rudder, the propeller serving the treble purpose of propeller, rudder, and reversing gear. The propeller is rendered strong and durable by being constructed of forged metal, while it is so arranged that the wearing parts can be renewed at a trifling cost. A special device also obviates the chance of corrosion of the wheel and its joints. The wheel is provided with a steering index which always points out to the steersman the direction in which the propelling force is exerted, enabling him to control it at will. Mr. Fowler's invention would appear to embody the perfection of manœuvring. Notably, it will turn a vessel on her own centre, either to the right or to the left, by steam alone; it will enable a vessel to follow a narrow and tortuous channel at full speed in backing; or to steam out of a narrow slip, where there is little or no room to go ahead or back, by squaring away sideways, or, again, to make a figure of eight around two stakes, placed half the length of the boat apart, either in going ahead or in backing.

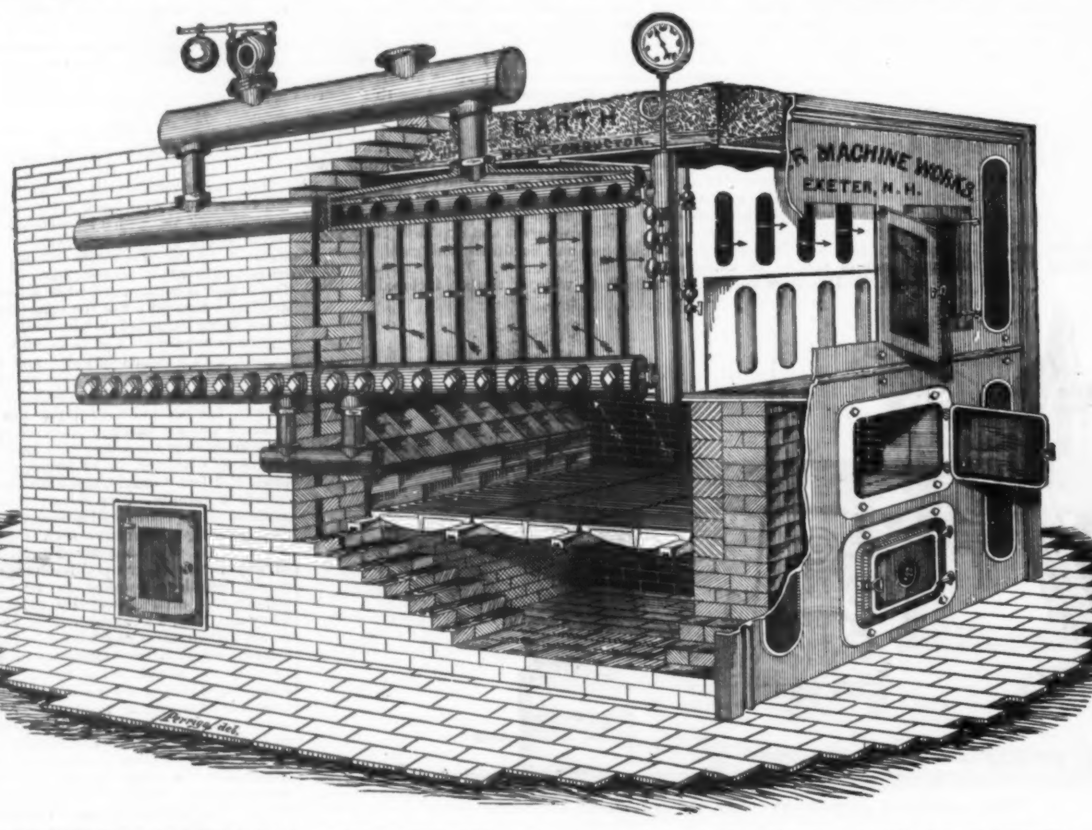
THE PARIS EXHIBITION OF 1878.

THE plan of the International Exhibition of 1878 has been issued by the Minister of Commerce. The main building on the Champ de Mars will be 689 metres long by 350 wide. The French section will occupy the left half of it, and the foreign sections the right. Visitors walking through it transversely will be able to see the "exhibits" of all countries in any particular class. The Fine Arts will occupy the Central Avenue, and will have five times the space allotted to them in 1867. The breadth of the avenues will be one of the most striking features of the building, the area of which will be 240,000 metres, as against 153,000 last time. There will be five departments—namely, machinery, raw material, furniture, clothing, and the fine arts. There will be a large hall decorated with statues at each extremity, one fronting the Trocadero and the other the Military School. The plan of the buildings on the right side of the river and of the connecting foot bridge is not yet settled.

STEAM BOILERS AT THE CENTENNIAL.

IN further illustration of the boiler exhibits (see SUPPLEMENT No. 45), we now present a larger illustration of the Exeter Sectional Boiler, exhibited by the Exeter Machine Works of New Hampshire, and shown in operation at Boiler House No. 3, in Machinery Hall.

This boiler consists of a series of sections, each of which forms a complete boiler of itself, of rectangular form, 3¼ feet long, 3 feet high, and 4 inches thick—the iron being ½ inch thick. Each section is of cast iron, with 12 openings running through it; these openings, 2 by 12 inches, serve not only to increase the heating surface, but their walls act as ties or stays tying the flat walls of the section together. Every angle or corner of the casting is rounded inside and out, and the bottom and top faces of each section have a wave-like form which permits of the necessary contraction and expansion.



THE INTERNATIONAL EXHIBITION OF 1876.—THE EXETER STEAM BOILER.

The sections are arranged over the fire on edge, and transversely to the line of the draught, with open spaces of from 1 to 2 in. diameter between them. The lower part of each section is connected by an extra heavy 2-inch pipe, extending through the wall of the setting to a main feed pipe outside, which feed pipe is common to all the sections. The upper part is connected in a similar manner to a main steam pipe. The main feed pipe has plugged openings directly on a line with the bottom of each section, through which the cleaning operations can be easily effected.

The connections used to join the sections with the outside branch ties are accurately fitted with a parallel thread for the end screwing into the branch tie, and with a taper thread to screw into the section, thus forming a perfectly reliable joint in the section, while the outside ties are provided with a lock-nut. Any section may be readily disconnected and removed from the top of the boiler without disturbing either the other sections or the brickwork. The brick walls differ from those of the ordinary tubular boiler only by having cast-iron plates to support the sections built into the side walls. The fire-brick lining the fire chamber can be replaced without disturbing the supports. A cast-iron T is built into the bridge wall to unite the supports, to allow for their expansion, and to prevent the spreading of the brick walls.

The boiler sections rest on their supports at distances sufficiently apart to allow for the expansion and contraction of the sections independent of each other. The brick walls are two inches from the section up one half of its height, where a heading course is laid to the section. By resting square bars of iron between the sections on these heading courses, the lower draught is completely isolated from the upper one, and is compelled to traverse between and along the sides of the lower half of the sections to the rear of the boiler, and thence up and back between the openings in the upper half of the sections to the chimney in front.

To test this form of boiler the makers have got up steam in one up to 400 lbs. per square inch, and then blow it off dry. The fires were continued until the sections assumed a dull red heat, when cold water was immediately pumped in the steam gauge rapidly indicating a pressure of 50 lbs. per inch. No explosion or rupture followed this unusually severe experiment.

The strains due to expansion and contraction, which strains are usually highly destructive, are undoubtedly obviated in the construction of this boiler, while its sectional character is a great element of safety, because it is of comparatively small consequence if a section should rupture, since the element of time which must elapse ere the contents of the boiler can be liberated is the most complete attainable safeguard against explosion. The combustion of the fuel is, in consequence of the large area of heating surface, very slow, and is as a natural consequence economical.

EXHIBITS OF JUTE MANUFACTURE.

MESSRS. LAWSON & SONS, of Leeds, England, exhibit a complete set of machinery on an extensive scale for preparing and spinning jute suitable for making yarn for cloth or for rope. Their display in Machinery Hall is so complete that visitors can see the whole process of preparing and spinning jute, from the raw material in bulk to the finished articles. The set comprises the following machines, covering a very large area of flooring: Breaker card, finisher card, first drawing, second drawing, roving, spinning, and cop machines.

In the manufacture of jute the raw material has to undergo a process known as "batching," in order to enable the machinery to break so harsh a substance. The process can be and is done either by hand or machinery. It consists in applying a certain quantity of oil and water to the material and then passing it between a number of fluted rollers, heavily weighted, in a machine called a "softener." The jute is then ready for the breaker card, in which it is fed on to an endless sheet moving toward a feeding roller. This roller takes hold of the fibre and retains it; while a large drum or cylinder, revolving at a high rate of speed, and having wooden lags fitted with very sharp steel pins on its surface, strikes the fibre and tears it asunder. At the same time the jute is carried forward to other rollers, similarly fitted with steel pins, which, in turn, clean and lay the fibre parallel, and from which the fibre is taken off by the "doffer," and delivered into a metal receptacle in front of the machine. The material has now the form of a sheet, or "sliver," as it is termed, and is ready for the second or "finisher" card. The name of this machine speaks for itself. Its action is much the same as that of the breaker card, only more finishing—that is, it lays the fibre still straighter and cleans it more, sufficiently so to render it fit for the first drawing frame, the fibre being now ready to be drawn into sizes, suitable for the different numbers required for spinning—number one, number two, etc. The first drawing frame has rollers and hackles, which carry the fibre forward to the drawer, where it is drawn and the different fibres of the material are laid as parallel as possible—the more parallel the more suitable for making good yarn. The machine is one of the latest brought out by the Lawsons, and consists of a chain gill in place of the old screw or rotary. This innovation, by the simplicity of its working parts, admits of double the amount of work being turned off, while it brings about a great economy of skilled labor. From the first the shoer is taken to the second drawing machine, in which it undergoes a similar process, reducing it still more. It then goes to the roving frame, on which, for the third time, it undergoes the process of drawing; but this time, instead of passing from this machine into a receptacle or case, as before, it is wound on to a bobbin, in the shape of the rove and having received a certain twist. The roving and drawing machines of the Lawson pattern are made so simple that should a lap or choke take place by reason of carelessness on the part of the attendant, the head stops, and the accident can at once be remedied, the others working on; for as each head is provided with a distinct motion, an accident to one or more can be repaired without stopping the whole machine. Other makers have adopted the principle of two shafts for bringing about the same result; but this requires more wheels, and involves more danger from gearing. The Lawsons have also introduced a more direct acting motion into their roving machine in the shape of a scroll in connection with the cone, in the place of the rack and pinion formerly used by them. This arrangement is far simpler, and produces a much better result.

The spinning frame is on the improved principle, having its drawing roller made wider on the faces of the bosses, thereby giving it a greater weaving surface. The roller can be moved from right to left by means of a screw. A very ingenious piece of mechanism is also displayed in having the iron plate move all at once, giving the desired angle. This is much better than the old practice of setting the plates, each head by itself, by screws. It saves a great amount of labor, and produces better results in spinning. The yarn, after being spun, is, in the case of weft yarn, carried to the "cop" machine, on which it is wound on to a spindle from the bobbin to the required size suitable for the shuttle. This is a great saving of labor compared with the old spool-cop machine. This machine is fitted with various mechanical motions, which can be set to suit the various sizes of yarn; a stop motion, which sets each spindle in case the yarn runs out or breaks, also a stop motion to give the required length of cop. The yarn is wound outside on to the cop, and when the cop is fixed in the shuttle, it is drawn from the inside, thereby saving much waste of yarn, and enabling more yarn to be put into the shuttle, and, of course, lessening the number of stoppages of the loom.

THE United States Centennial Map has just been placed in the west end of the Government Building. It was prepared for the Exhibition at the General Land Office, and is 17 feet in height by 22 feet in length, and divided into nine sections, each mounted on a separate stretcher. The whole is enclosed in a massive frame of walnut, bird's-eye maple, and ebony, and weighs 2000 pounds. It shows the extent of all surveys, Indian and military reservations, land grants, railroads, canals, cities, and towns, and, in fact, every possible detail, from the most authentic sources.

LOCOMOTIVE TESTS.

THE Committee of Master Mechanics have issued the following circular:

DEAR SIR: The undersigned, a committee appointed at the annual convention of the American Railway Master Mechanics' Association to report on the subject of "Locomotive Tests," respectfully desire the co-operation of members of the Association in furnishing to them any record of tests they have made, or may make prior to next annual meeting.

1st. Comparative tests of several classes or kinds of locomotives, as to number of cars hauled by each class, giving weight and dimensions of each class; pressure steam carried; kind and quality of fuel consumed; miles run; kind of exhaust, single or double nozzle; diameter nozzle; condition of road, grades, curves, etc.

2d. Have you made any tests in burning fuel in locomotives; and what kind gives best results as regards economy? State whether plain fire-box, water-table or brick arch was used. If convenient, please give sketch of same, including stack and arrangement in smoke-box.

3d. Give results of any tests of a general character that will be of interest and value to the Association.

The Committee desire the members to give the Association the benefit of their experience relative to the above subject, that it may be placed on record for reference. A blank form is here appended, in which the weight and dimensions of engines can be conveniently entered.

Very respectfully, WM. WOODCOCK,
Master Mechanic, Central Railroad of New Jersey,
S. A. HODGMAN,
Master Mechanic, Phila., Wil. and Balt. Railroad,
DAVID CLARK,
Master Mechanic, Lehigh Valley Railroad,
Committee.

Replies should be addressed to Wm. Woodcock, Master Mechanic, Central Railroad of New Jersey, Elizabeth, N. J.

NEW STEAM FERRY, LONDON.

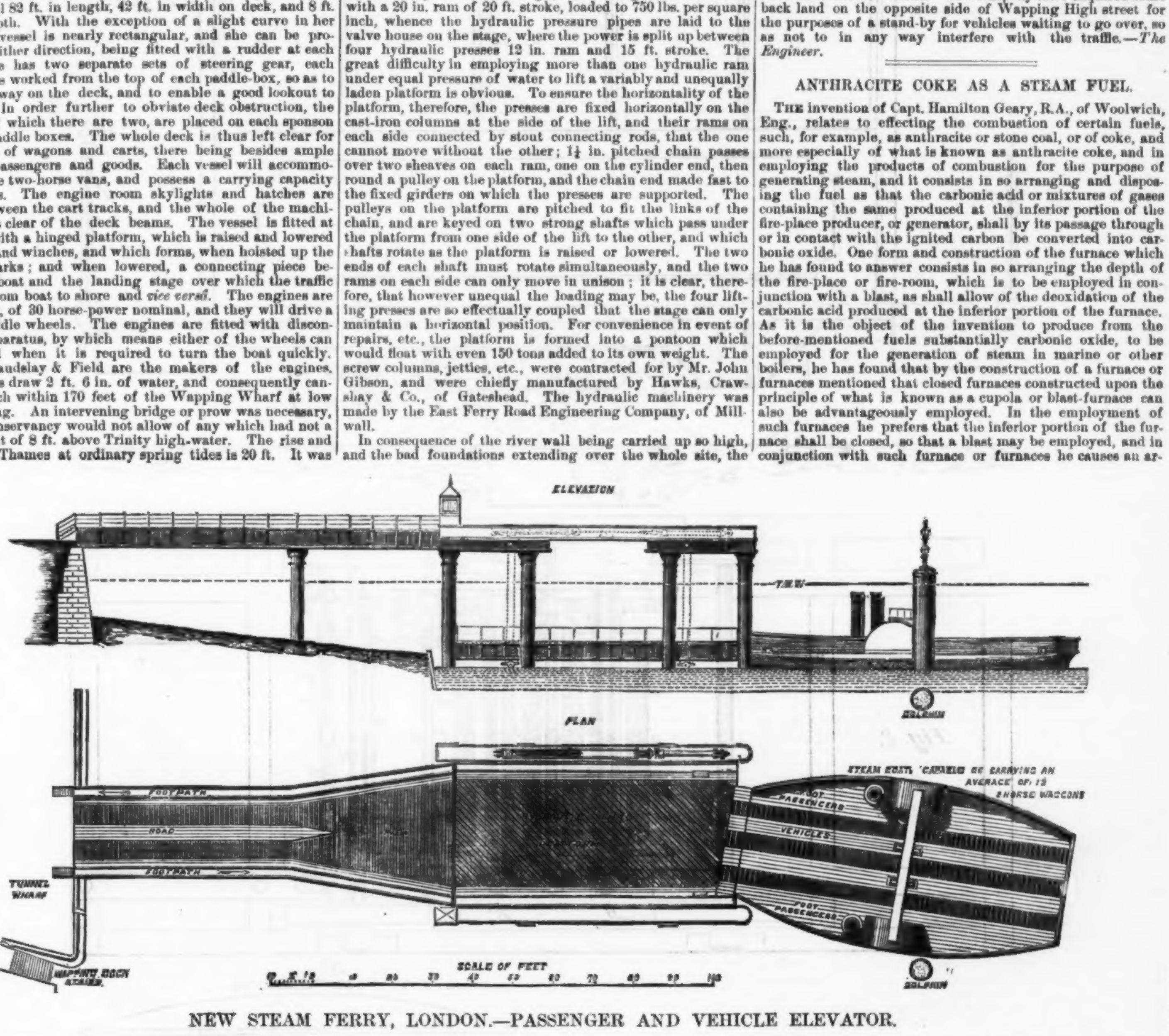
A GIGANTIC ELEVATOR.

A LARGE number of the members of the Society of Engineers lately visited the works of the Thames Steam Ferry Company, now in progress at Wapping. Mr. Waller, managing director, read a paper which gave a short history of the origin of the company and a description of the works.

The boats, of which the Jessie May is one, and the other soon to be launched, are built by Messrs. Edwards & Symes at their yard at Cubitt Town. The Jessie May is an iron built vessel 82 ft. in length, 42 ft. in width on deck, and 8 ft. 9 in. in depth. With the exception of a slight curve in her sides, the vessel is nearly rectangular, and she can be propelled in either direction, being fitted with a rudder at each end. She has two separate sets of steering gear, each of which is worked from the top of each paddle-box, so as to give clear way on the deck, and to enable a good lookout to be kept. In order further to obviate deck obstruction, the funnels, of which there are two, are placed on each sponson near the paddle boxes. The whole deck is thus left clear for three rows of wagons and carts, there being besides ample room for passengers and goods. Each vessel will accommodate twelve two-horse vans, and possess a carrying capacity of 50 tons. The engine room skylights and hatches are placed between the cart tracks, and the whole of the machinery works clear of the deck beams. The vessel is fitted at each end with a hinged platform, which is raised and lowered by chains and winches, and which forms, when hoisted up the end, bulwarks; and when lowered, a connecting piece between the boat and the landing stage over which the traffic will pass from boat to shore and *vice versâ*. The engines are condensing, of 30 horse-power nominal, and they will drive a pair of paddle wheels. The engines are fitted with disconnecting apparatus, by which means either of the wheels can be stopped when it is required to turn the boat quickly. Messrs. Maudslay & Field are the makers of the engines. These boats draw 2 ft. 6 in. of water, and consequently cannot approach within 170 feet of the Wapping Wharf at low water spring. An intervening bridge or prow was necessary, but the Conservancy would not allow of any which had not a clear height of 8 ft. above Trinity high-water. The rise and fall of the Thames at ordinary spring tides is 20 ft. It was an engineering problem, therefore, to devise a safe and expeditious means of transferring a boat load of horses and vehicles as well as foot passengers, weighing some 50 tons, through a vertical distance of 28 ft. from the boat's deck to the floor of a fixed jetty, and to lower a similar load from the jetty to the boat at least once every quarter of an hour. The well known hydraulic lift apparatus, with a single ram, could only deal with the traffic in detail, taking up and down but one or two vehicles at a time, and except by providing some six or eight of such lifts, and a large floating stage on which the traffic to and from the boats might be received, there was no possibility of the work being done in the quarter of an hour interval. This plan, it may be mentioned, was suggested by one of our most eminent engineers. Messrs. Clark & Standfield made a very good proposition, which was to bring the boat between two rows of hydraulic rams, somewhat similar to their Victoria ship-lift, and by suitable attachments lift the boat's deck with its entire freight to and from the required levels, and this, but for the necessity of carrying out the piers 50 ft. further into the Thames, and so seriously interfere with the navigation of the river, would possibly have worked well. Another scheme was to have a large platform on which the traffic could draw from the boats, and a long winding drum on shore with eight or ten heavy chains passing from it over pulleys to as many attachments on the platform, the drum to be worked by a steam engine of about 120 horse-power. The directors gave due consideration to these proposals, and one simultaneously submitted by Mr. F. E. Duckham, of the Millwall Docks. The proposers or their representatives were interviewed by the board, whose sole object was to obtain the best lift for their purpose. Mr. Duckham's lift was selected, and he was appointed the company's engineer for carrying out the works designed by him—the works which are now nearly completed. A jetty 100 ft. long, 19 ft. 6 in. wide for 60 ft., and fanning out to 33 ft. at the outer end, is formed by wrought-iron plate girders, supported on cast-iron screw columns. The proper floor of the jetty is to be set apart for vehicles, and the economy as to space and cost, as also for the comfort of the foot passengers themselves, the footpaths to and from the lift are placed on top of the side girders. A platform is provided of a sufficient area to accommodate both the outward and inward freight. Upon commencing its work the platform forms a continuation of the roadway and footpaths of the jetty. It is proposed that the outgoing vehicles occupy the two outside of the four ranks on the platform, and the outgoing passengers the top of the right-hand girder. As the boat approaches, the platform will be lowered to the deck level and the machine locked. The vehicles on the boat will then draw off to the two vacant centre ranks of the platform, the foot passengers to the top of the left-hand girder. The outgoing traffic will move on to the boat, the boat will leave for the opposite shore, the platform be raised to its first position, its freight transferred to the roadway, and the process repeated. To accomplish this a hydraulic engine of 25 horse-power is employed, supplied with steam by vertical boilers 4 ft. 6 in. diameter, by 12 ft. 6 in. high, and having an accumulator with a 20 in. ram of 20 ft. stroke, loaded to 750 lbs. per square inch, whence the hydraulic pressure pipes are laid to the valve house on the stage, where the power is split up between four hydraulic presses 12 in. ram and 15 ft. stroke. The great difficulty in employing more than one hydraulic ram under equal pressure of water to lift a variably and unequally laden platform is obvious. To ensure the horizontality of the platform, therefore, the presses are fixed horizontally on the cast-iron columns at the side of the lift, and their rams on each side connected by stout connecting rods, that the one cannot move without the other; 1¼ in. pitched chain passes over two sheaves on each ram, one on the cylinder end, then round a pulley on the platform, and the chain end made fast to the fixed girders on which the presses are supported. The pulleys on the platform are pitched to fit the links of the chain, and are keyed on two strong shafts which pass under the platform from one side of the lift to the other, and which shafts rotate as the platform is raised or lowered. The two ends of each shaft must rotate simultaneously, and the two rams on each side can only move in unison; it is clear, therefore, that however unequal the loading may be, the four lifting presses are so effectually coupled that the stage can only maintain a horizontal position. For convenience in event of repairs, etc., the platform is formed into a pontoon which would float with even 150 tons added to its own weight. The screw columns, jetties, etc., were contracted for by Mr. John Gibson, and were chiefly manufactured by Hawks, Crawshay & Co., of Gateshead. The hydraulic machinery was made by the East Ferry Road Engineering Company, of Millwall.

In consequence of the river wall being carried up so high, and the bad foundations extending over the whole site, the directors, after careful consideration, decided to build vaults under the roadway from Wapping High street to the jetty, and this portion of the work is now completed; the foundations for the walls have been carried down to a depth of 19 ft. below street line, or 21 ft. below Trinity high-water, and over the whole surface the ground has been excavated and concrete filled in to a depth of 6 ft. 6 in. to render the vaults free from damp; and with a view to further security a layer of asphalte has been put in the middle of the concrete to prevent any water rising, and this being weighted with 18 in. of concrete will prevent the water ever blowing it up. Arches on piers and cast-iron girders have been turned at the requisite height in two half-brick rings in cement, and the crown and haunches of arches filled in with Portland cement concrete. Penrhyn granite trams and curbs have been laid down, the space between the trams being filled in with wood paving, similar to that in King William street, City, and the footways will be formed on each side, and rendered in Portland cement. The gradient of the roadway, 1 in 16, is a little steep, owing to the great height required by the Thames Conservancy for the jetty to be kept up; but from the great care taken in forming the roadway with the wood paving and granite trams, no difficulty is anticipated with the traffic. The work to this point is now completed. The whole of the ground floor is given up to the roadways, the traffic on and off being kept distinct; various offices are provided at the entrance. The height of this floor will be 16 ft. from floor of the jetty to under side of the girder on the river front, and at the street front 18 ft. to under side crown of arches. These large openings will be filled in with suitable revolving iron shutters; the floor over the roadway will be fireproof, and consist of wrought-iron girders and bow strings filled in with concrete. The superstructure over the roadway and on the adjoining wharves will, when completed, form an imposing block of warehouses, six floors in height; at the level of the girder over roadway, a moulded string of red Dumfries and Portland stone will be carried through, and above this the building will be in Kent stocks with some red-brick bands. The reveals to door and window openings and arches will be built in blue Staffordshire bricks, the whole finished with a moulded brick and stone cornice with a centre gable. The warehouses will be fitted with hydraulic cranes.

The works on the Rotherhithe side have not been of so extensive a character. A similar accumulator house and engine shaft have been built as those on the Wapping side, and the engine house will shortly be completed. Improvements are being made in the approaches on this side, and negotiations are going on for the acquiring of more land for the purposes of a stand-by, and with a view to meet the projected improvements of the Metropolitan Board of Works in this neighborhood. The whole of the works executed have been done in the most substantial manner, under the direction and superintendence of the company's architect, Mr. Alexander R. Stenning, of 27 Fenchurch street, the general contractors being Messrs. Lee & Son, of Westminster, Messrs. Moreland & Son, of Old street, supplying all the iron work. Mr. W. W. Browne is clerk of works. The company have acquired some back land on the opposite side of Wapping High street for the purposes of a stand-by for vehicles waiting to go over, so as not to in any way interfere with the traffic.—*The Engineer.*



NEW STEAM FERRY, LONDON.—PASSENGER AND VEHICLE ELEVATOR.

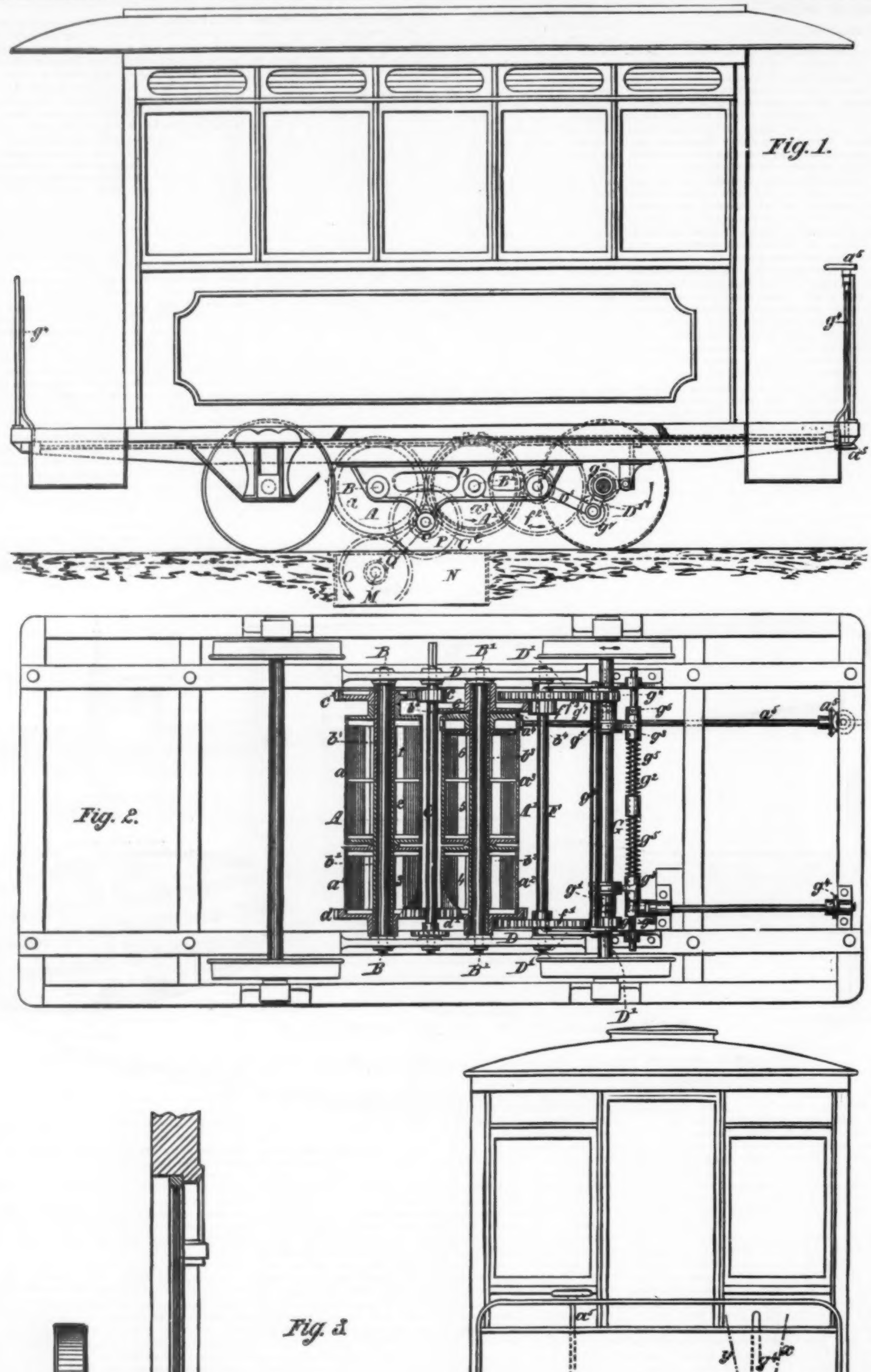
ANTHRACITE COKE AS A STEAM FUEL.

THE invention of Capt. Hamilton Geary, R.A., of Woolwich, Eng., relates to effecting the combustion of certain fuels, such, for example, as anthracite or stone coal, or of coke, and more especially of what is known as anthracite coke, and in employing the products of combustion for the purpose of generating steam, and it consists in so arranging and disposing the fuel as that the carbonic acid or mixtures of gases containing the same produced at the inferior portion of the fire-place producer, or generator, shall by its passage through or in contact with the ignited carbon be converted into carbonic oxide. One form and construction of the furnace which he has found to answer consists in so arranging the depth of the fire-place or fire-room, which is to be employed in conjunction with a blast, as shall allow of the deoxidation of the carbonic acid produced at the inferior portion of the furnace. As it is the object of the invention to produce from the before-mentioned fuels substantially carbonic oxide, to be employed for the generation of steam in marine or other boilers, he has found that by the construction of a furnace or furnaces mentioned that closed furnaces constructed upon the principle of what is known as a cupola or blast-furnace can also be advantageously employed. In the employment of such furnaces he prefers that the inferior portion of the furnace shall be closed, so that a blast may be employed, and in conjunction with such furnace or furnaces he causes an arrangement to be made as is well understood, so that the combustible gases produced in such cupolas or other blast-furnaces shall be conducted to the marine or other boiler, and be employed for the generation of steam. In order to effect the more effectual combustion of the combustible gases generated and employed in the manner mentioned, he inserts a perforated pipe or tube, or a series of perforated pipes or tubes, in the combustion chamber of the boiler, through which he causes air to be injected, so as to commingle with the gases to be consumed. [This seems to be a substantial copy of the invention of T. S. C. Lowe, of Pa., which has been successfully used for several years in this country.]

THE WATER SUPPLY AT WOOLWICH.

THE water pumped from the artesian wells for the use of the troops at Woolwich, which filtering through the Kent chalk-beds is unusually pure, but also unusually hard, is now softened by adding to it a concentrated solution of lime, in the proportion of nine ounces to forty gallons, which precipitates bicarbonate of lime, the hardening constituent. The lime-water, if used pure, also coagulates and precipitates any dissolved organic matter. In four or five hours the hardness of the water is reduced from twenty-one degrees to six degrees, a result which could also be produced by the expensive process of boiling the water for two hours. The process works successfully, a million gallons being completely purified as easily as one gallon.

COST OF THE GREAT ISTHMUS CANAL.—John C. Trautwine, an engineer of great experience, who was connected with the construction of the Panama Railroad, and who made an exploration for a canal by what is known as the Atrato route, says that no canal can be constructed across the Isthmus, which will be satisfactory, for less than $300,000,000. He holds that it would not be possible to construct a canal on the most favorable route, without having tide-locks at either end. The rise of the tides along the Pacific shores of the isthmus ranges from sixteen to twenty feet, while the rise on the Atlantic side averages only about two feet. He thinks that at least two tide-locks will be necessary, in order to check the current which otherwise would flow through the canal with a strength which would materially impede navigation.



SPRING MOTORS.—SPRING-PROPELLED STREET RAILWAY CAR.

SPRING MOTORS.

A SPRING-PROPELLED RAILWAY CAR.

By E. H. LEVEAUX, Hammersmith, Eng.

WE continue from SUPPLEMENT No. 46 our series of papers on Spring Motors.

The object of the present invention is to effect an economy in the working of tramways, adapted for the accommodation of street traffic.

Supposing the ordinary form of street car to be employed, I utilize a portion of the space below the floor of the carriage by arranging therein a series of barrels containing coiled springs, and connected with the driving-wheels of the carriage. These springs, when wound up by the means to be presently described, will serve as a stored power for propelling the carriage.

In the accompanying drawings, Fig. 1 is a side elevation of a tramway-carriage, fitted according to this invention, and showing the mechanism applied thereto for winding up the coiled springs. Fig. 2 is an inverted plan view of the same, with the barrels in section. Fig. 3 shows, in elevation (applied to a tramway-carriage), the mechanical arrangement which I employ for winding up the springs of such carriages.

Below the floor of the carriage, and near the middle of its length, I arrange groups of spring-barrels, two only being shown in the drawings; but any greater number may be used if found convenient. These barrels A A′ are fitted loosely upon sleeve-arbors (see Fig. 2), which arbors are strung upon the axles B B′. C is the winding-shaft, which has its bearings in side frames D, fitted to the under side of the carriage, which frames also form bearings for the axles B B′. The manner of driving the shaft C will be hereafter described. The group of barrels A consists of two barrels, a and a^1, and the group A′ consists of the barrels a^2 a^3. The barrels a and a^3 are made of double the width of the barrels a^1 and a^2, so as to contain each two springs. These barrels a a^1 a^2 a^3 are mounted loosely on their respective sleeve-arbors b b^1 b^2 b^3. The first sleeve-arbor b, strung upon the shaft B, is of length sufficient to pass only half way through the barrel a; but the other sleeve-arbor, b^1, extends from the middle of that barrel and through the next barrel a^1 to the side frame. The sleeve-arbors on the shaft B′ are arranged in like manner, the sleeve-arbor b^2 being only of sufficient length to reach to the middle of the barrel a^3, and the sleeve-arbor b^3 strung on the same shaft extending from b^2 to the side frame.

The springs 1, 2, 3, 4, 5, and 6 are arranged within the two groups of barrels in the following manner: The inner coil of the spring 1 is attached by a hook to the sleeve-arbor b, which is made fast to the axle B, on which the first barrel a is mounted loosely. The outer coil of this spring is attached to a hook on the inner periphery of the barrel a. Within this barrel a is the second spring 2, having its coils in the reverse direction to the first spring, and attached in a similar manner, the outer coil to a hook in the barrel, and the inner coil to a hook on the second sleeve-arbor b^1. Within the barrel a^1 is fitted the spring 3, with its coils in the reverse direction to those of the spring 2, and the end of its innermost coil is attached to the arbor b^1, and that of the outermost coil to a hook on the barrel a^1. This group of barrels and springs A is coupled with the adjoining group A′ by spur-gear. d is a spur-wheel attached to or forming part of the barrel a^1 of the group A, and into it gears a similar spur-wheel d^1, made fast to or forming part of the barrel a^2 of the group A′. Within this barrel a^2 the spring 4 is fitted, as before explained, it being connected at its opposite ends to the barrel a^2 and to the sleeve-arbor b^2. To the inner end of the sleeve b^2 is attached the spring 5, its coils being in reverse direction to those of the spring 4. The end of its outermost coil is attached to the barrel a^3, and the end of its innermost coil to the sleeve b^2. This barrel a^3 also contains the spring 6 attached at its opposite ends to the barrel and sleeve-arbor b^3. Near one end of the winding-shaft C is a pinion, c, which gears with a spur-wheel, c^1, made fast to the arbor b of the barrel a. Near the opposite end of the shaft C is a ratchet-wheel, the retaining-pawl of which is attached to the frame D to prevent the running back of the winding-shaft. The sleeve-arbor b^3 carries a pulley embraced by a friction-strap, which serves to fix the sleeve, and prevent its rotation when desirable.

In winding up the springs the clutches g^1 g^1, described hereafter, are to be in gear when the brake is not in use, so as to stop the running down of the springs. The shaft C is rotated, and by means of the gearing c c^1 and d d^1 the train of springs is coiled up. Made fast to the sleeve b^3 is a ratchet-wheel, b^4, into the teeth of which takes a pawl, carried on the inner face of the spur-wheel e, which wheel runs loosely on the sleeve-arbor b^3. Gearing into the spur-wheel e is a pinion, f, keyed on the shaft F. This shaft has its bearings in the side frames D, and serves to communicate, through spur-gearing f^1 and f^2, rotary motion to the axle G of the running wheels. On the axle G two pinions, g g^*, are mounted loosely, and on their bosses clutch-teeth are formed to receive, respectively, the teeth of a pair of clutches, g^1, which slide on feathers on the shaft G, and are operated by the clutch-rod g^2.

This pair of pinions and clutches are used for the purpose of driving the carriage in opposite directions, as desired. The clutch-rod g^2 is mounted on the side frames, so as to be capable of being traversed endwise by the reversing-lever g^4, and is provided with two loose sleeves or bosses, g^3, from which project the forks which embrace the sliding clutches. Around the clutch-rod g^2 are two helical springs, g^5, separated by a loose central collar, or it may be one spring extending from one sliding fork to the other. These helical springs, g^5, being in compression, will bear the clutch-forks against the fixed collars g^6 on the clutch-rod g^2, and keep their respective sliding clutches in gear with the pinions g g^*, when the reversing-lever g^4 is in its intermediate position, thereby stopping the running down of the springs and admitting of their being wound up.

The pinion g on the shaft G is driven direct from the spur-wheel f^1 on the shaft F, as before explained; but the pinion g^* is driven through the intermediate pinion g^7 from the spur-wheel f^2 on the shaft F, and, therefore, the pinions g and g^* are driven in opposite directions, as indicated by the arrows. When it is required to drive the carriage to the right hand, (as seen in side elevation), the reversing-lever g^4 is to be thrown into the position indicated by the dotted line x in Fig. 3; the clutch-rod g^2 will be thereby slidden endwise and cause one of its fixed collars g^6 to press against the sleeve of the fork and move the sliding clutch out of gear with the pinion g and compress the spring of the opposite clutch and hold it in gear with the pinion g^* more firmly. The power stored in the springs is then allowed to drive the axle G of the running-wheels through the spur-wheel f^2, the intermediate pinion g^7, and the pinion g^*, on the driving-axle G, and thereby give motion to the carriage. This intermediate pinion g^7 is carried by a shaft, g^8, which has its bearings in radius-links D^1 pendent, respectively, from the shafts F and G. When, however, the direction of the carriage is to be reversed the reversing-lever g^4 is thrown into the position indicated by the dotted line y of Fig. 3, by which means the acting-clutch will be slidden out of gear and the idle clutch will be thrown into action, when motion will be thereby transmitted to the shaft G from the spur-wheel f^1 on the shaft F direct to the pinion g, thus transmitting motion to the driving-axle in a reverse direction to that given to it when the motion was transmitted to it through the intervention of the intermediate pinion g^7.

The means above described for connecting the groups of spring-barrels with the axle G of the running-wheels admits of the spring-power being held back, when desired, by means of the brake a^4 forming part of the ratchet-wheel b^4. This brake is operated through the connecting-shafts and gearing a^5 from the platform of the carriage. A brake of the ordinary description is also to be applied to the running-wheels for the purpose of stopping the car.

I will now describe the means which I employ for winding up the spring-barrels. Along the track or course to be traversed I provide a series of motive-power engines, arranged at suitable distances apart—say, a convenient length for a run. The places at which these engines are situate will form stopping stations, where passengers may alight from or enter the carriages. While this is taking place the engine will be employed in winding up the springs, so as to prepare the carriage for continuing the journey.

Referring to Figs. 1 and 3, I is the shaft of a stationary engine, which serves to give motion to a belt-wheel, K, the belt from which passes to a pulley, L, keyed to a horizontal shaft, M, which shaft is supported in bearings placed below the roadway, and, for the sake of convenience, enclosed in a metal casing or tube. Close to one side of the tramway-track, over which the carriage is intended to run, a box, N, is sunk in the roadway, and through this box passes the shaft M. Keyed onto the shaft, within the box, is a spur wheel, O (see also Fig. 1), which gears with a spur-wheel carried by a pair of radius-arms, Q, which have for their support the shaft M. The axle of the spur-wheel P is fitted with a sleeve, so shaped as to connect with the winding-axle C of the carriage and to permit of its instant disconnection therefrom when required. The box N is fitted with a lid to cover the gearing when out of action. When it is desired to wind up the spring-barrels the carriage is brought up to position, as shown at Fig. 1. The lid of the box N is thrown back and the spur-wheel P is raised to the dotted position and the sleeve of its axle is slidden into connection with the shaft C. The engine I is then set in motion, and by means of its connection with the shaft M it will cause the spur-wheels O and P to rotate, and through the sleeve or other couplings give rotary motion to the shaft C and thereby wind up the spring-barrels. To prevent overwinding, a friction coupling may be introduced at any convenient part of the apparatus, or a means of forcibly disconnecting the sleeve or other coupling from the shaft C may be provided. When the spur-wheel P has been disconnected from the carriage it will be returned to its depressed position and the lid of the box will be closed. It will, of course, be necessary to provide that the stored power of the springs shall more than suffice for completing the run to the next station in order to avoid the possibility of the carriage being brought to a standstill before the power can be renewed. On the arrival of a car at any station, the spring-barrels are quickly wound up by the engine."

SIZE, WEIGHT, AND POWER OF THE SPRINGS.

It has been computed that the actual tractive force, requisite to overcome the resistance of a street car weighing gross 5 tons, is 60 lbs. on the driving wheels, corresponding to 720 lbs. on the periphery of the spring barrel; 24 lbs. and 288 lbs. respectively correspond to a gross weight of 2 tons; and in like proportions for intermediate weights. So far as previous experience goes, a spring 6 lbs. in weight, exerting a direct pressure of 105 lbs., may be taken to represent the maximum in size and power of such steel springs. Under the stimulus applied by M. Leveaux's researches, the steel manufacturers of Sheffield, by special and improved plant, annealing ovens, and appliances, have turned out springs 50 to 60 feet long, capable when duly coiled of exerting a pressure of 800 lbs. to 900 lbs., without permanent set. In France, also, steel driving bands with great elasticity are made, 100 yards in length, so that the question of the possibility of obtaining springs of the requisite size and power is practically solved.

M. Leveaux has had all the necessary mechanism and appliances made by a well-known firm of engineers, so as to fit up a tramway car or cars for actual trial upon some of the lines of metropolitan tramways in London; for which, indeed, the arrangements are now nearly complete, so that the practical working of the system will speedily receive a thorough public demonstration. We have ourselves, says *Iron*, had opportunities of seeing the potentialities of the principle, both in the model and full working size; and even in view of the sweeping change in the tramway system which is involved in its complete success and adoption, we can not withhold the conviction that all the important practical difficulties have been effectually surmounted, reducing its practical realization to mere matters of detail. The working of the springs is entirely free from noise, perfectly smooth, easy, and effective, and completely under control, for application, cessation, and reversal.

ON WELDING IRON.*

WHEN we bend a piece of iron, or stretch it, or twist it, or compress it, we experience a certain amount of resistance to motion. It requires a considerable force to compel the molecules to change their relative position within the limit of elasticity, and still more to change it permanently.

The attraction of the iron for itself holds the atoms a fixed distance apart, which is unalterable except by the exertion of a force greater than itself. If, on the other hand, the iron were rendered gaseous, the atoms would become perfectly mobile and self-repellent. When it is in a liquid state, the condition is neutral, and when it is viscous the attraction, to a certain extent, predominates. It is this attraction which effects the welding, and during the process it will inevitably expel any intervening liquid substance, which is less viscous than itself, provided the liquid has a chance of escaping.

If two globules of mercury, immersed in water, or even a more dense fluid, are made to approach each other, they will readily unite on a slight concussion. So soon as the metal comes within atomic distance, the fluid is expelled, and the weld is perfect. If the globules are covered with a film of oxide or dust, it becomes more difficult to obtain metallic contact, and the globules rebound instead of uniting. This leads us to a fair conception of what welding means.

It is the common boast of a good smith that he can unite two pieces of iron so firmly as to give way in any other part rather than the joint. Here is a sample of a bar which has been welded in the middle. Under a strain of nineteen tons it has given way, but not at the weld, and we may be sure that this could never be the case if welding were only a process of gluing. In reality, the splice ought to be the strongest part of the bar, because, in addition to joining, the process is also one of doubling and re-drawing.

As regards the means of obtaining complete metallic contact, the skill of the workman has to be exercised—1st, in heating the iron sufficiently; 2d, in protecting the surfaces from oxidation by means of a flux; 3d, in forming the surfaces in such a way that the flux has a means of escape when the ends are closed up under the hammer. The natural flux is, of course, the oxide of iron which forms during the process of heating; but this of itself is of an infusible character, and a welding heat not being a melting heat, it is liable to resist union by its very dryness. The workman, therefore, assists the fusibility of the oxide by the addition of a silicious sand. The office of silica in the operation is thus twofold; it unites with the oxide to form a glass which is fusible at a comparatively low temperature. The glass overflows the heated part and protects it from further oxidation, while its fluidity enables it to be more easily expelled when the union takes place.

It is often remarked that silica is the great enemy of iron, and when present in excess this is certainly the case, because then its own infusibility comes into play. When used with judgment and in the proper proportions, it is indispensable as a means of obtaining the requisite condition of fluidity. There are certainly better fluxes than silica, as for instance borax, and a mixture of silica and alumina is better than silica alone. The flux commonly used in Sheffield for welding cast steel is a dried brick clay, a sample of which, as analyzed by Mr. N. Samuelson, contains:

	Per cent.
Silica	58.50
Alumina	32.95
Peroxide of iron	4.65
Lime	3.25
Magnesia	0.54
	99.89

The essentials of a good flux are in all cases a readiness to combine with the oxide of iron, and fusibility at comparatively low temperatures when so combined. We thus see that although much silicon in pig iron is undesirable in the puddling process a certain quantity is advantageous, and even necessary, while it plays a most important part in the subsequent processes. Even in the thinnest film it performs its office, and when iron is worked over and over again, it is still present, constantly diluting and constantly permitting closer and closer metallic contact.

When we trace the action of this basic silicate in some operations, we meet with results which are really extraordinary. I have here a small piece of a large armor plate, kindly furnished by Mr. Ellis, of the Atlas Works, Sheffield. The plate, when finished, measured 14 ft. 16 in. x 5 ft. 4 in. x 2 ft., and weighed 31 tons. In order to show the amount of welding which took place in the manufacture of this plate, let me observe that the whole is made out of puddled balls weighing a little over 1 cwt. each, while every puddled ball consists of thousands of metallic globules originally not larger than peas. The puddled bars made from these are cut, piled, and re-rolled; and the process of piling and re-rolling is repeated up to six times. We thus arrive at the somewhat astonishing fact, that the entire mass consists of not less than 11,448 distinct laminæ, and that each inch contains 528 such laminæ. In the sample before us, the cross section has been subjected to the action of dilute hydrochloric acid, in order to exhibit the grain. It will be seen that the structure, although it can not be called absolutely homogeneous, is little inferior to really homogeneous or melted iron. This is, of course, owing in a great measure to the extreme extenuation of the small quantity of cinder which remains in the mass after welding. Consisting, as the plate does, of six successive operations of piling and rolling, the last weld will enclose most cinder, and the first least for equal areas. What the enormous area is, over which the cinder of the first pile is spread, I leave those skilled in figures to calculate, and to draw their own conclusions. It is sufficient to say, that the plate altogether forms a remarkable proof, or rather upwards of 11,000 proofs, of the efficacy of welding.

I will now draw attention to the system adopted at Low Moor, which is also a system of welding, although essentially different from the foregoing. Quality being the great object aimed at, regardless of cost, the most minute care and precaution is taken at every stage of manufacture. The process in forming a plate is as follows: The pig iron is smelted with cold blast, from materials comparatively free from both sulphur and phosphorus, and is afterwards refined. It is then puddled in heats of not more than 2½ cwts., with the addition of nearly ½ cwt. of scrap, consisting of finished plate shearings. The puddling process ended, the balls are hammered, each into a separate slab. These are then reheated, and doubled and reheated and doubled again, until the requisite weight has been attained, and the whole is then reduced by hammering (involving fresh reheating) to a slab of the proper dimensions and shape for the rolls. The rolling presents nothing unusual, except in one important respect. The slab is not rolled with the original laminations horizontal, but vertical or cross-grained. This is a precautionary measure for detecting flaws. If there is a blister or defective welding anywhere concealed in the mass, it is more likely to appear at the surface of the finished plate by this method than by the ordinary plan of rolling with the laminations parallel to the rolls. Nothing could afford a more striking proof of the reliable nature of a sound weld than this mode of manipulation, producing, as it does, work of such excellence. If the plate once passes inspection, no trace of the lines of junction is seen.

In the manufacture of bars, even greater precautions are taken than in that of plates. Every slab from the puddled ball is, in this case, broken in two and the fracture examined. Every piece which seems to have been at all burnt, or which presents a shelly appearance, is rejected and laid aside for common purposes. Those which pass muster are made into piles, which are hammered and doubled as described above, previous to rolling; while, for best cable iron, the blooms are not rolled into the finished section direct, but into flat bars, which are again cut up, piled, and re-rolled.

The reason for these extra precautions is this. In plates (which, being for boiler purposes, are not usually very thick), any flaw is almost sure to make its appearance at the surface; but in bars, especially of large diameter, it is possible for a defect to exist in a centre, where it would escape detection.

I need scarcely add that the conditions of a sound weld are

* From a paper read at the Leeds Meeting of the Iron and Steel Institute, by Mr. Richard Howson.

nowhere more appreciated than at these works, and the greatest care is exercised at every stage, even to the extent of employing an inspector, whose duty it is to examine every slab and remove every speck of dirt or shell which may appear on its surface, before it is put into the furnace.

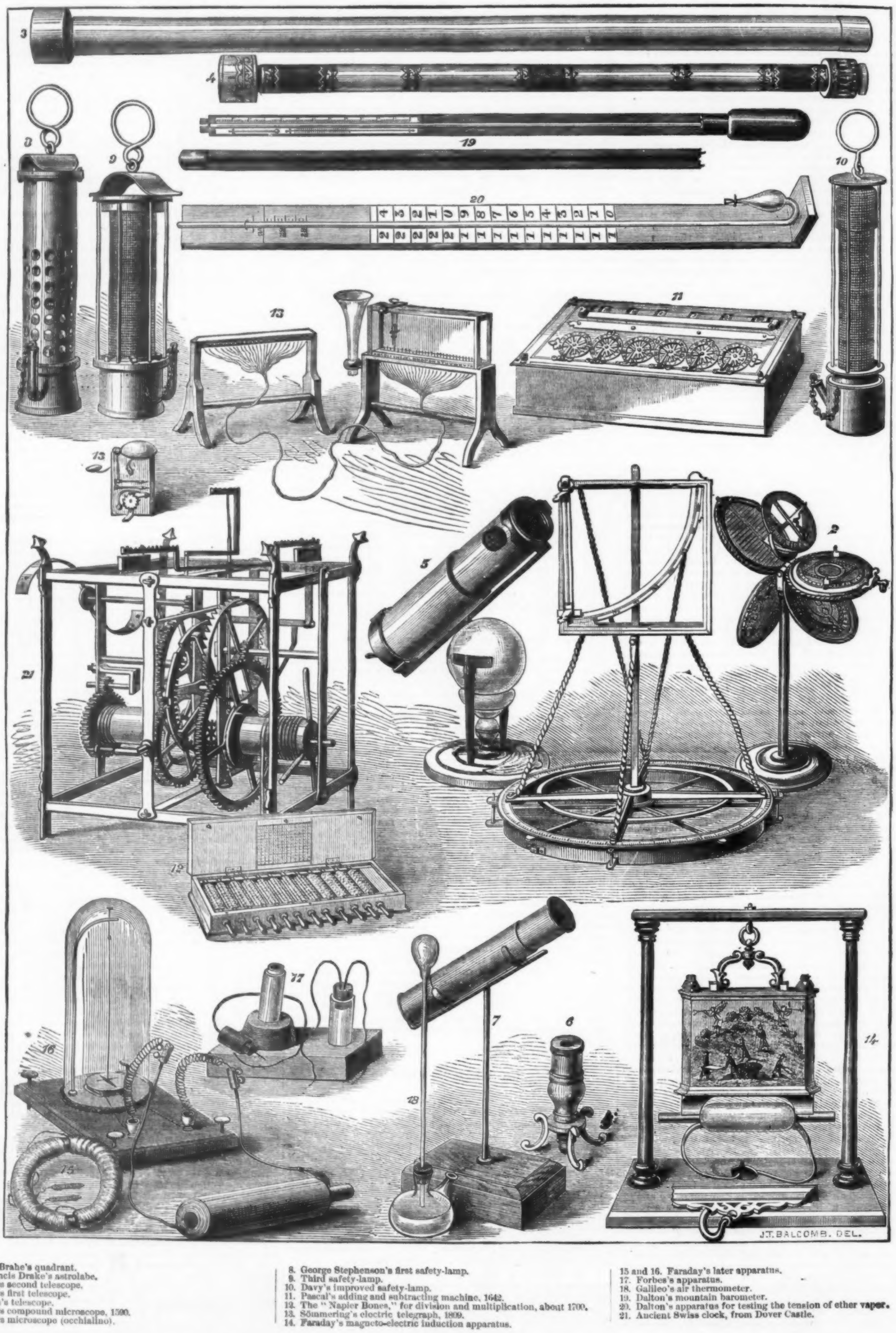
I will now shortly recapitulate the points to which I have endeavored to call the attention of the meeting:

1. When two surfaces of wrought iron in a half-melted or viscous state are pressed together, the intervening cinder is expelled, provided it is liquid enough, and has a chance of escape, and cohesion results. This constitutes a weld, and if the proper conditions have been fulfilled, such a weld will be as sound as any other part of the bar.

2. The requisite conditions are seldom, if ever, absolutely fulfilled in practice. When the surfaces to be united have a large area, it is impossible to avoid enclosing some small quantity of cinder. The endeavor should be to reduce it to a minimum, and then dilute it by after working.

3. Shingling a puddled ball is essentially a process of welding, and the term homogeneous is altogether inapplicable to it.

4. The conditions for perfect welding are in no case favorable in a puddled ball, and the difficulty increases with its size.—*Engineering.*



1. Tycho Brahe's quadrant.
2. Sir Francis Drake's astrolabe.
3. Galileo's second telescope.
4. Galileo's first telescope.
5. Newton's telescope.
6. Jansen's compound microscope, 1590.
7. Galileo's microscope (occhialino).
8. George Stephenson's first safety-lamp.
9. Third safety-lamp.
10. Davy's improved safety-lamp.
11. Pascal's adding and subtracting machine, 1642.
12. The "Napier Bones," for division and multiplication, about 1700.
13. Sömmering's electric telegraph, 1809.
14. Faraday's magneto-electric induction apparatus.
15 and 16. Faraday's later apparatus.
17. Forbes's apparatus.
18. Galileo's air thermometer.
19. Dalton's mountain barometer.
20. Dalton's apparatus for testing the tension of ether vaper.
21. Ancient Swiss clock, from Dover Castle.

HISTORICAL TREASURES IN THE LOAN COLLECTION EXHIBITION OF SCIENTIFIC APPARATUS, LONDON.

EXHIBITION OF THE LOAN COLLECTION OF SCIENTIFIC APPARATUS, LONDON.

In the Official Handbook to this Exhibition at South Kensington it is stated, among other things, that "it was desired to obtain objects of historic interest from museums and private cabinets, where they are treasured as sacred relics." In our page of illustrations, with the following description, we present some of these treasures, and give a brief historical account of them.

EARLY ASTRONOMICAL INSTRUMENTS.

Astronomy, so far as instruments are concerned, is an applied science. Its history is written in the special adaptation of these instruments to its needs. We begin with the measurement of angles, and end with a wide range of implements, illustrating the application of almost every branch of physical and mathematical science, including optics, heat, electricity, chemistry, and dynamics. Each new instrument introduced has by no means abolished the preceding one—accretion, rather than substitution, has been the rule. Angles are now better measured because the telescope has been added to the divided arc. Instead of the clepsydra, we now use the pendulum to divide time, and electricity helps to record it. We also inquire into the cause of the color of the stars by the aid of the spectrum. The telescope has grown in power; and almost all phenomena can be photographically registered.

Astronomy divides itself into two groups, mechanical and physical. The earliest is the mechanical, which was that introduced by Hipparchus (160 B.C.). He produced the first instrument by which positions could be noted on any part of the celestial vault—"extra-meridional" observations, so called. His astrolabe and other instruments are the foreshadowings of the *Armillæ aliæ* and the *Armillæ zodiacales* of Tycho Brahé, and of the modern altazimuths and equatorials. In measurements Hipparchus used the moon as a standard. In Tycho's measurements a planet was the criterion; hence the greater accuracy of his work, represented in this collection by a quadrant, one of the most interesting relics in the museum (No. 1). Tycho used plain sights, which were pointed to the object. The circles were divided into minutes of an arc; and, by using transversals, or a diagonal scale, the arc was divided down to ten seconds. All his observations were made with the naked eye. Instrument No. 2 is the astrolabe constructed for Sir Francis Drake, previously to his first expedition to the West Indies, in 1570. It was preserved in the Stanhope family till 1783, when it was presented to King William IV., who, in 1833, deposited it in Greenwich Hospital. It is about 9 in. high.

GALILEO'S ORIGINAL TELESCOPES.

Now passing to the physical side of astronomy, the means of getting and utilizing a great quantity of light, we come to telescopes. We need not enter into the question of the actual invention of the refracting telescope; it is quite clear that Galileo, whose instruments have been forwarded from Florence, was the one who first used it with the greatest success. At that time the object-glass rarely exceeded an inch in diameter, sometimes not so much, and it became necessary to correct the chromatic aberration by making the focus as long as possible; the first telescopes, therefore, resembled walking-sticks.

No. 3 is Galileo's second telescope, the object-glass of which is 50 mm. in diameter, eye-glass plano-concave. It served for his most important discoveries and experiments. Constructed by himself, in 1610, it is of wood, covered with brown paper, about 5 ft. 3 in. long. No. 4 is his first, the object-glass of which is 38 mm. in diameter, eye-glass double concave, 19 mm. in diameter. It was made by himself; about 4 ft. long, covered with leather, ornamented with gold. Some later lenses reached the enormous focal length of 360 ft. Some of these are in the collection.

SIR ISAAC NEWTON'S TELESCOPE.

It was the opinion of Newton, who lived in the time of these long lenses, that the improvement necessary to correct the colored effects of dispersion was "desperate." Reflection was therefore suggested. No. 5 is Newton's telescope. On the brass plate on the base is the following description: "The First Reflecting Telescope invented by Sir Isaac Newton, and made with his own hands in the year 1671." It is about 10½ in. high, the tubing of cardboard, eyepiece ebony, rings iron, ball and base of wood.

EARLY MICROSCOPES.

Simple instrumental appliances have been used by students of the biological sciences from the earliest times. Before the sixteenth century zoology and botany, with no other aid than simple instruments, as knives, scissors, saws, forceps, pins, and hooks, had made very considerable progress. No. 6 is the first compound microscope; it was invented and constructed about 1590 by Zacharias Jansen, spectacle maker, at Middleburgh, Netherlands. It is a rough iron tube, with glass lens at each end. No. 7 is Galileo's microscope, then called Occhialino. It is of brass, and stands about 5 in. high.

SAFETY LAMPS.

Our next subject is the safety-lamp. Previous to its introduction the resources of chemical science had been fully applied in ventilation, and the comparative lightness of the fire-damp was well understood. Sir James Lowther had observed, early in the last century, that the fire-damp was not inflammable by sparks from flint or steel, and a person in his employment had invented a mill for giving light by the collision of flint and steel. There is a mill like this in the South Kensington Loan Collection. This was the only instrument for giving light, except common candles, employed in British collieries. Yet this mill was not thoroughly safe. In Flanders amadou, or fungus tinder, had sometimes been employed in mines, but its light was too feeble. Baron Humboldt, the philosophical traveller, in 1796, constructed a safety-lamp, founded on the principle of excluding the light entirely from the air, consequently it only burnt till the air within was exhausted. Dr. Clanny, in 1813, contrived a lamp similar as to insulation, but he supplied his light with air from the mine through water by bellows. The light went out in explosive atmospheres. This lamp required manual or mechanical labor to work it. In the year 1814 a deadly explosion took place in the Killingworth Colliery, when George Stephenson descended, at the risk of his life, to investigate and afford assistance. By the aid of six volunteers he built a wall across the fired workings, so as to exclude the air and extinguish the flames. Having succeeded in so doing, some one asked him if such accidents could not be prevented. He thought they could. The Clanny lamp had been tried, but was too cumbrous. Sir Humphry Davy had been engaged, at the request of a committee of coalowners, in careful research concerning the action of fire-damp and flame; but George Stephenson had also been experimenting in his own way, and on October 21, 1815, he put his new lamp to the test (No. 8 in our illustration). It is of glass, with a perforated shield. Not satisfied, he made a second, and, in 1816, yet a third lamp (marked No. 9), of glass surrounded by gauze. His are distinguished as "Geordie" lamps. All this time Sir Humphrey Davy was also experimenting. His first safe lamp was of fine wire-gauze, in the form of a cylinder, closed with gauze at one end, at the other by soft moulded clay, in the centre of this a common candle. An opinion prevails amongst the "Newcastle folk" that Geordie Stephenson invented the safety-lamp first because he observed, on one occasion, "that the flame of the candle did not pass through the small apertures of the latticed fender, and gathering from this fact the rude idea of a safety-lamp." In 1818 this opinion took a tangible form in the shape of a silver tankard containing 1000 guineas, presented to him in the Assembly Rooms at Newcastle as the "discoverer of the safety-lamp." In May of the same year Sir H. Davy collected and published in a connected form all the papers he had written on this subject; and it must be evident from the originality of his experiments (the rudiments of his apparatus are deposited in a neighboring case in the Loan Collection) that he required no borrowed genius, that the ideas he worked out were his own, and that Stephenson and Davy were independent laborers in the same field, obtaining similar results by different means, like Daguerre and Talbot in photography, who both reached the same end by entirely distinct paths. The merit may be accorded thus: To Davy that of ascertaining scientifically the law of the safety-lamp; to Stephenson the credit of finding out by actual experiments in the pit how a light could be made safe when carried into a cloud of inflammable gas. Davy's matured lamp—marked No. 10—was made about 1820, and is of single gauze. The North of England Institute of Mining and Mechanical Engineers, who contribute all the safety-lamps, give a table which points out that generally the safety-lamps constructed with glass in addition are the more safe.

CALCULATING MACHINES.

Under the class arithmetical instruments are placed counting machines. The art of counting or of enumeration is perhaps the earliest product of nascent civilization, and among savage races affords no unfair measure of their degree of intellectual development. There are tribes whose numeration goes no higher than twenty. It is quite certain that no nation ever acquired the ability to count by thousands without possessing a high average of mental capacity, and the privilege of producing occasionally men of inventive genius and real leaders of thought.

A clock is defined by Sir John Herschel as a machine for counting and recording the oscillation of a pendulum.

A pedometer is an instrument for counting and recording the number of steps by the person carrying it.

An apparatus attached to a wheel revolving along a road, or a turnstile which shows the number of persons admitted, are simple instances of counting-machines. But such as are adopted to more varied and complicated uses are the achievements of mathematical skill.

An instrument was invented and constructed by the celebrated Blaise Pascal, when nineteen years of age, in 1642, for the addition and subtraction of sums of money (No. 11).

The next (No. 12.) is the "Napier Bones" (now obsolete), made about 1700, used for performing division and multiplication, invented by Baron Napier, the originator of logarithms. A simpler and probably more modern form of the "bones" consists of five rectangular rods, their faces divided into squares, etc.

There is in the exhibition a difference-engine, serving to calculate tables of analytical functions, which was invented by the late Charles Babbage. It occupied the later years of his life. In 1842, after an expenditure of £17,000 by the Government, its expense was alleged as the reason for abandoning its completion.

THE FIRST ELECTRIC TELEGRAPHS.

Electricity, magnetism, and electro-magnetism have demanded instruments of great variety. Bishop Watson, in 1747, transmitted the electrical contents of a Leyden jar through 10,600 feet of wire, suspended on wooden poles, at Shooter's Hill, near London. A plan for an alphabetical telegraph is described in the Scots' Magazine for 1753: this was not experimentally realized. At Geneva, were tried, in 1774, wires, each connected with a pith-ball electroscope, every pith ball a letter. Frictional electricity was here tested, but was found too difficult to manage. Volta's discoveries, the galvanic electricity being more continuous, paved the way for the subsequent unfolding of electric-telegraph history.

No. 13 is the original apparatus of Th. Sömmering, made by him in Munich in 1809. It was the first electric telegraph worked by galvanism, with a Volta pile, silver and zinc plates; about 9 inches high.

Modern magnetism dates from the year 1600. It was then for the first time clearly shown by William Gilbert, physician, of Colchester, that the earth possesses magnetic properties.

The polarity of the needle, the variation of the compass, the magnetic dip, were, indeed, displayed by George Hartman, Vicar of St. Sebald's, Nuremberg, before Duke Albert of Prussia, in 1544. These discoveries were intrinsically of fundamental importance, but they went no further. On the other hand, the unbroken line of descent dates only from the publication of Gilbert's work, which has never been lost sight of, and ever since recognized as the starting-point of accurate magnetic science.

FARADAY'S ELECTRICAL INSTRUMENTS.

The relation of magnetism to electricity was finally established in the most triumphant manner, when Faraday succeeded in causing the loadstone to produce a current of electricity of exactly the same kind as the chemical combinations of the voltaic circle; so, whereas Oersted showed that electricity could yield magnetism, Faraday pointed out the means of making magnetism yield electricity.

No. 14 represents his Siberian loadstone and spark apparatus employed by him in his experiments on magneto-electric induction, from which he first obtained the induction spark. The base is covered with red cloth; the supports are of ebony; the loadstone is contained within the picture; the helix, immediately under and in the centre of the bar of iron, is covered with red leather; the whole about 22 inches high.

No. 15 is the original apparatus by which, in 1831, he obtained the magneto-electric spark. It consists of a welded ring of soft iron, 6 inches diameter, ⅞ inch thick, one part covered by an helix of 70 feet of insulated copper wire, the other part by a second helix containing 60 feet of the same. These helices are divided at each end by a space of uncovered iron. The iron ring was converted into a magnet by passing a voltaic current through the 70-feet helix; a current was thus induced in the 60-feet one, and a small spark was for a moment seen at the carbon terminals.

No. 16 was made in the same year, and is his original apparatus for magneto-electric induction by a permanent magnet. It consists of a cylindrical iron-bar magnet, over this a pasteboard tube surrounded by a helix of copper wire, the terminals of which are connected with the galvanometer, under the glass. So long as the iron remains in the helix, currents of electricity are induced, which cause a deflection of the suspended galvanometer needle. The whole is about 14 inches high.

No. 17 is the apparatus by which Forbes, in 1833, procured an induction spark from a natural magnet. It is of 4 inches of deal, a large cork, two glass tubes, in one a coil of paper, in the other a cork, secured with sealing-wax, from which wires proceed. The separate part is a wire through the centre of two corks.

EARLY THERMOMETERS AND BAROMETERS.

No. 18 is the air thermometer, in the form first given to it by Galileo.

With regard to the atomic theory, it is to our countryman Dalton we are indebted for the first development and demonstration of the fact that bodies unite in definite proportions. The atoms he considered as spheres, and represented them by appropriate symbols. An interesting collection of apparatus used, and much of it made, by him, is contributed by the Philosophical Society of Manchester. Dalton devoted much of his time to meteorology. No. 19 is his mountain barometer, with accompanying thermometer; it is enclosed in a wooden case. This he was accustomed to carry in his hand. No. 20 is an apparatus used by him for the determination of the tension of the vapor of ether, and is interesting as being the instrument by which he arrived at one of his most important experimental laws—the law of tensions. Almost all the apparatus of Dalton is of a somewhat rude description; this gives it the more interest, knowing as we do the immense results he obtained with their aid. The one under notice is no exception to this, being made by him of deal, the central figures and lines being written on paper, which is pasted on. The originals of 19 and 20 are about 3 feet long.

EARLY TIME-PIECES.

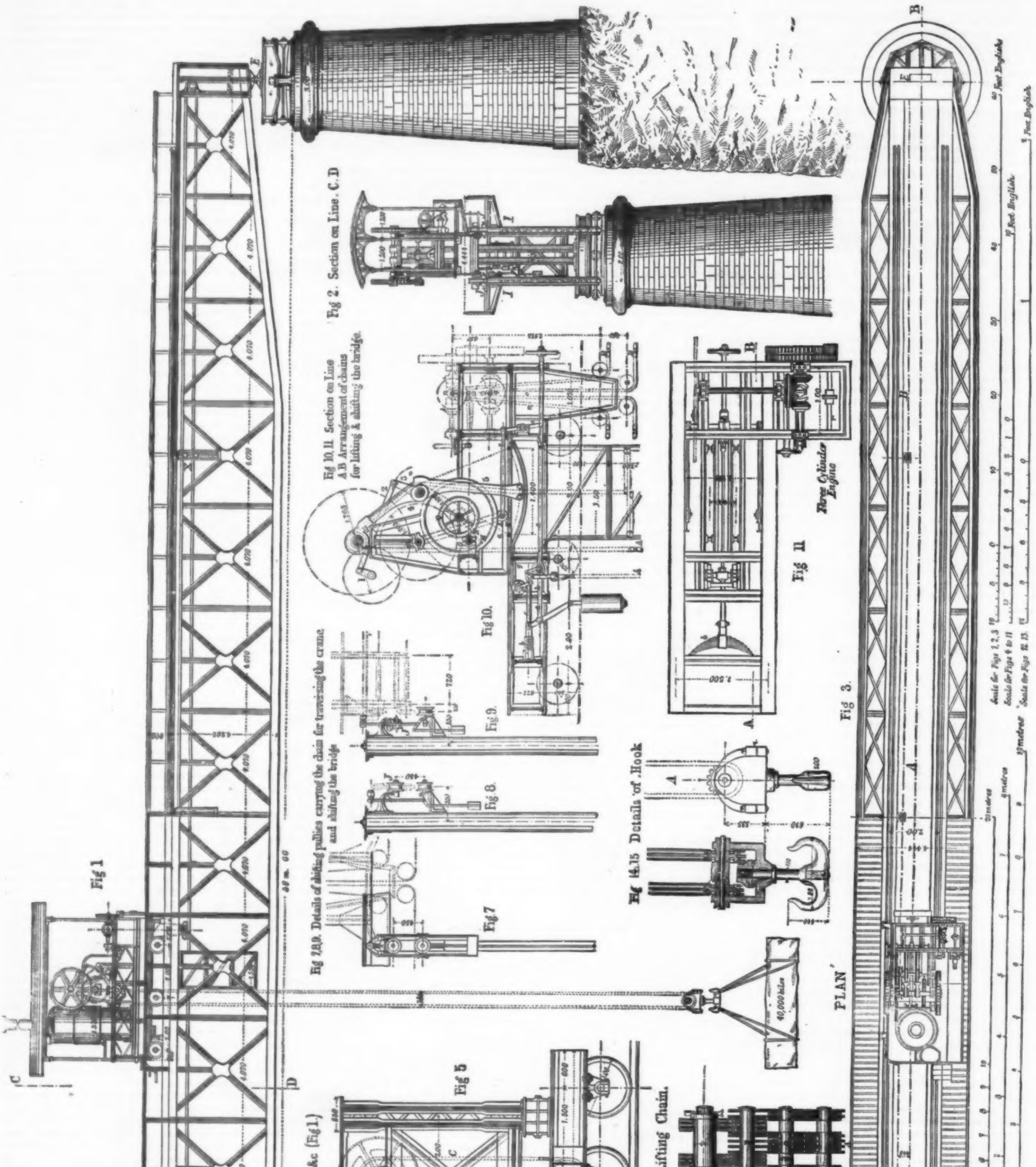
Among the instruments used for measurement of time, there is an ancient striking clock (No. 21) of Swiss manufacture, and made about 1348. It was long in Dover Castle, and is interesting in having the verge escapement regulated by the balance, with weights at top; this was very much older than the pendulum. The strong hold which the planetary motions appear to have taken on the minds of our forefathers is shown in the first clock of which we have any authentic account—that by Wallingford, Abbot of St. Albans. This gave the hours, apparent motion of the sun, changes of the moon, ebb and flow of the tides, etc. But the first thoroughly reliable description of a clock is that of De Wyck, a German, erected in the tower of the palace of Charles V., King of France, in 1379. If the date assigned to the subject of our illustration be correct, it is, therefore, the oldest clock in existence.—*London Illustrated News.*

NEW MUSICAL IMPROVEMENT.

Baillie Hamilton recently gave a lecture on his new Æolian Tones, at the lecture room of the South Kensington Museum, W. H. Stone, Esq., M.D., in the chair. Mr. Hamilton explained the growth of the conception from the well-known Æolian harp, modified by making the wind play through jambs on only a part of the string, by flattening that part of the string, and, as in Mr. Farmer's wind-violin, by attaching the string to the extremity of a free-reed, which was moved by a bellows. Mr. Hamilton then stated how he had attempted to modify Mr. Farmer's arrangement by having strings attached at each end to fixed supports in the usual way, and also attached at some portion of their lengths by upright rods to harmonium reeds. The tones thus obtained were very beautiful, but there were practical objections which had now been overcome by considering that the string acted only as a constraint upon the motion of the reed. According to Mr. Hermann Smith, the air in a reed organ-pipe acted in the same way, and even in a flue organ-pipe, because there was then really formed an æro-plastic reed. Acting upon this observation, Mr. Hamilton and Mr. Smith had tried whether other elastic constraints which had not the same practical inconveniences as strings would not answer the same purpose. Various contrivances by means of metal and other springs were tried with various degrees of success, and at last an extremely simple, cheap, and effective method had been discovered. A piece of brass wire was soldered at one end to the frame enclosing an harmonium reed, or metal tongue, the end of the wire pointing to the fixed end of the reed, and the point of attachment being much nearer the free end. Then this wire was bent round in a circle, and, passing through a little loop or staple affixed to the upper part of the reed, was carried three or four inches further, coming out beyond the free end of the reed, and forming a sort of proboscis, bent like that of a butterfly. By drawing the wire through the staple, the circle could be made tighter or looser, much modifying the constraint. By straightening or curling up the proboscis, the pitch could be flattened or sharpened more than an octave, so that tuning to any pitch could be effected without filing the reed. By modifying the form of the circle into a more or less flat ellipse, or even making it rhomboidal, different qualities of tone were produced. Several specimens of the tones were sounded, and a harmonized air was played. The effect was that of a very rich organ tone, entirely free from the usual defects of the harmonium-reed tone. There is now no doubt that a great discovery in the production of musical tones has been accomplished, and that a more convenient instrument than the organ can be produced at a very much smaller cost, and with qualities of tones in some cases superior, in others equally good, although for others opinions may differ. But the present simplicity has been attained by very hard work for several years, and a long, varied, and expensive series of experiments.

SIMULTANEOUS OSCILLATIONS OF THE BAROMETER.

Mr. J. Allan Broun has printed in the last number of the *Proceedings* of the Royal Society two papers on these oscillations, which have already attracted so much attention. He starts with those observed in India, which he shows to be inexplicable by any theory of connection by currents, and to closely resemble the changes in terrestrial magnetism. In the second paper he discusses the great barometrical oscillation, March 31–April 5, 1845, at stations varying in position from Makerstown to Hobarton, and shows that from the simultaneity of the phenomena they must be due to a cosmical cause such as he indicates.



REVOLVING BRIDGE AND TRAVELLING CRANE AT THE THIARMONT QUARRIES, BELGIUM.

DESIGNED AND CONSTRUCTED BY MM. J. B. CORNET AND E. THOMAS.

NEW REVOLVING BRIDGE AND TRAVELLING CRANE.

THE accompanying engravings show a very efficient and novel combination of revolving bridge and travelling crane, recently established at the quarries of Thiarmont, Belgium. The work was designed by M. J. B. Cornet, of Thiarmont, and has been executed by M. E. Thomas, of Brussels. The arrangement consists: first, of a revolving bridge, pivoted at E at one end, and resting upon a suitable carriage at the other, which runs freely upon a circular rail laid around the circumference of the quarry; second, of a steam travelling crane able to lift 40 tons, and running to and fro the whole length of the bridge. The construction of the bridge and of its points of support are shown in Figs. 1 to 6. From these it will be seen that the total length is 196 ft. 10¼ in. and the length of span is 190 ft. 3¾ in. It consists of two main girders 13 ft. 11¼ in. deep in the centre, placed parallel, and 6 ft. 6¾ in. apart from centre to centre. The depth of the girders at the ends is 9 ft. 7$\frac{1}{16}$ in., and each girder is divided in its whole length into fourteen panels 13 ft. 4$\frac{3}{16}$ in. apart. They are finished with plate-iron ends as shown, stiffened with T-irons 20$\frac{1}{16}$ in. and 17$\frac{1}{16}$ in. apart. The ends are also braced together by webs stiffened by angle irons, as shown, and by diagonal vertical braces of angle iron. As the crane travels from end to end with the lifting chains hanging clear between the girders, the latter can not be strengthened by any horizontal bracing. To increase the stability of the structures, the platforms running along the whole length of the bridge are made as shown in Figs. 2 and 3, formed of cantilevers 13 ft. 4$\frac{3}{16}$ in. apart, connected together at their outer ends by a light auxiliary girder, and by horizontal diagonal bracing. That end of the bridge resting upon the central pier is supported upon a pivoted joint bolted to a horizontal beam set in a circular frame. Between this latter and the rail circle laid on the top of the pier, are a number of wheels arranged radially like those of a turntable, and the whole structure revolves around a central pivot. The supporting carriage at the other end is shown to an enlarged scale in Figs. 4 and 5. It consists of a wrought-iron frame 14 ft. 9 in. long, 15 in. deep, and placed 4 ft. 5¼ in. apart from centre to centre. Cross beams of the same depth connect these frames, and carry the pivoted joints upon which the girders rest. The carriage runs upon six wheels 39¼ in. diameter, and on the axle of the central pair is placed a toothed wheel, over which passes the pitched chain by which the bridge is caused to revolve. The mechanism for effecting this will be presently described. The general arrangement of the travelling crane is shown in Figs. 1, 2, and 3, and the details in Figs. 10 and 11. The lifting power of the crane is obtained from a three-cylinder Brotherhood engine driving the shaft M, on which is a friction pinion N. The pinion drives the friction pulley by contact on its inner side P, and by another pulley Q made in one piece with O, but of much smaller diameter. By this means any desired range of speed is obtained according to the load to be raised. The contact with P or Q is effected as follows: The pulley O is mounted on a shaft running in bearings bolted to a pair of levers jointed at their upper ends, as shown. The lower ends are connected to a double lever and a crank controlled by a handwheel, so that the friction pinion may be thrown into contact either with P or Q. It will be readily seen that according to the variations in the loads to be raised, it would be necessary to make frequent adjustments with the handwheel. This would have the effect of producing undesirable shocks on the machine, and it is avoided by the means shown in Figs. 10 and 11. The end *a* of the double lever can be controlled either by the handwheel, or by the action of the spring *b*, acting on the rod *c*, connected to the double lever at *a*. The box of the spring is coupled by a rod *g* to a link *q* to which is attached one end of the lifting chain. This link *q* is movable under the load, and as the latter increases, the spring flattens under its action, moving the rod *c*, and acting through this and the whole system of levers which control the pulley O, producing a variable pressure on the pinion N. The weight shown in Fig. 10 counterbalances the suspended portions of the mechanism, and tends always to produce friction between the pinion and the pulley N.

The rotation of the bridge and the travel of the crane is effected by means of an endless pitched chain which extends the whole length of the bridge and passes over pulleys at each end, as shown in Figs. 1, 4, 5, and 6, and gives motion to the central axle of the travelling carriage upon which the outer end of the bridge rests. The chain is also connected with the crane, as shown in Fig. 10. The upper and lower lines of chain are deflected by rollers, up into the crane, where they pass around toothed wheels at *o* and *q* respectively, and these receive motion through the bevel gearing, shown in Fig. 11. By employing different combinations with the sliding clutches, the various movements required for the bridge and the crane are obtained. In order to complete the function of the gearing and to work it separately or independently, the shafts of the wheels *o* and *q* can either of them be stopped independently of the other by means of the brake *s*. Fig. 10 shows also the mode employed for lifting. Attached to the framing of the crane and between the girders is a box to contain the chain. By means of suitable gearing, and through the levers 1, 2, 3, and the shaft 4, a reciprocating motion is given to the lever 5, the lower end of which describes an arc, as shown by the dotted line; the lifting chain passes from below around a toothed wheel on the main shaft, down beside the lever 5, and between the small cross pieces at the bottom of it. By the reciprocating motion above alluded to, the chain is gradually lifted and deposited, as shown, in the box. The endless chain moving the bridge and crane is supported at intervals, as shown in Fig. 1, and in details Figs. 7, 8, 9, by small pulleys, the upper of which is suspended so that it may be thrown down out of the way when the crane passes. To effect this there is an inclined plane on the frame of the crane, which coming in contact with the projection at the end of the vertical rod attached to the bracket carrying the upper roller, raises it in passing (see Fig. 9) and throws the roller down; after the crane has passed, a reverse plane brings the bracket back into its place.

This system of revolving bridge and crane has been in use at Thiarmont since December, 1875, with excellent results. We are indebted to our contemporary the *Revue Industrielle* for the foregoing particulars and illustrations of this work.—*Engineering.*

TEMPERATURE OF THE INTERIOR OF THE EARTH.

FROM observations made on the well of Sperenburg, near Berlin, M. Mohr concludes that at the depth of 5170 feet the increment of heat must be nil. A similar decrease of the increment of heat has been observed in the Artesian well of Grenelle. Hence M. Mohr draws conclusions unfavorable to the Plutonian theory.

[The Building News.]

CARPENTRY.

IF masonry was of value, carpentry as a science and a discipline is of much greater consequence. The greatest minds have deemed it worthy of study. Vitruvius, Palladio, De Lorme, Perronet, and our own Sir Christopher Wren have placed carpentry in the highest position among the arts of construction, and the masterpieces of those illustrious architects still attest superiority. But as mental discipline to the young architect we consider carpentry the mathematics of architectural knowledge. Of course we mean as a science; though the descriptive and practical branches of the art are of no less moment. In the present series we shall enter into the mechanical theory, the descriptive and geometrical principles, as well as the practical part of carpentry. It is our intention, however, not to restrict our questions to any particular order, as we believe in this as in other subjects theory and practical exemplification should go hand-in-hand.

ELEMENTARY REPLIES.

QUESTION 1. *Define the kinds of timber used for carpentry and joinery.*—The principal kinds of timber used in carpenter's and joiner's work are oak, fir, and pine. Oak is used in both carpenter's and joiner's work. Its principal properties are strength, durability, and hardness. It is used in positions subject to exposure to the weather, as in the case of sills, etc. In mediæval times it was used for the construction of roofs, doors, etc., but at the present day its cost has brought Memel fir into use for the general purposes of roof construction. Oak has also a tendency to warp and twist, which renders it unsuitable in some framed structures. It is used for ornamental furniture and carving, principally for ecclesiastical purposes. Fir is of two principal kinds—the red or yellow fir, and the white fir. The Baltic redwood is used chiefly for the purposes of carpentry and joinery in preference to the white fir. It is by far the most durable of the fir or pine species. The wood is specially adapted for the purposes of joists and general framing. It is chiefly exported from the ports of Riga, Dantzic, and Memel. For carpenter's work it is usual to specify the best yellow Christiania deals and Memel yellow fir, and for joiner work the best yellow Christiania, Gottenburgh, or Gefle deals, to the exclusion of Swedish timber, which is considered inferior. The white fir is used sometimes for internal joiner's work, but is not so strong as the red wood, or so durable. Pine wood is of four principal kinds—the yellow pine, used for joiner's work; the red pine, used for similar purposes, and stronger than the yellow; the white, a similar but very inferior wood to the white fir; and pitch pine, a wood very durable, but difficult to work, used in England chiefly for floors, dados, etc., on account of its grain. Mahogany, ebony, and walnut are also occasionally used in ornamental joiner work.—T. N.

QUESTION 2. *To what strains is timber subject in building?*—The following are the principal strains to which timber in various positions, etc., is subject: 1. Longitudinal compression, as in the case of rafters, wood pillars (whose length does not exceed twenty diameters), etc. In timbers placed obliquely, in addition to the longitudinal compression acting in the direction of the length, there is also the cross strain produced by their own weight. There are cases where the compressive strain does not act in direction with the axis of the pillar or strut. 2. Transverse compression, as the pressure of a wall on the wall-plate, the force acting perpendicularly to the fibres of the wood. 3. Longitudinal extension, as in the case of a queen or king-post. The extension of a beam in the direction of its length being comparatively small, it is of very little practical value. 4. Cross strain, or a force tending to fracture the timber transversely, as in the case of girders, etc. When a beam is subjected to cross strain its upper fibres are compressed, and its lower ones in a state of tension, and that part of beam not subject to strain is termed the "neutral axis." The strength of a beam refers to its power to resist fracture, and the stiffness of a beam to its power to resist deflection. The rules to find the strength of a beam to resist a given load are regulated by the kind of load—whether uniformly distributed, whether a dead or living weight, etc. 5. Torsion is a strain appertaining more to iron than timber construction. 6. The resistance to detrusion is a name given to the tendency the timber particles have, in some positions, to slide upon each other. 7. The resistance to resilience, or the force required to resist the force of a moving body, is of more importance in iron construction.—T. N.

QUESTION 3. *What precaution should be taken at the bearing ends of timber?*—Timbers at their bearing ends should rest upon piers or solid portions of walls where possible, and not over openings, as windows, etc., unless these openings are bridged by a girder. Beams at their bearings should be so placed that their weight may be spread over as great a breadth of wall as possible by means of a stone template of large dimensions. Where such beams act as ties to the walls they should be secured to these templates by iron calking plates let into grooves in the stone and into the beam ends. The weight of any walling above should be carried by a cover-stone resting on the masonry at the sides of the beam, or by a small discharging arch if the timber is of large size. Iron shoe plates are perhaps the best protection for beam ends, keeping back the moisture arising from the masonry or walling in which they are built. A clear air space should be left all round the ends, except the actual bearing; this will do much to prevent decay. Where joists cross a partition wall which is to support another wall above, the spaces between them should be bricked up, dry against their sides and just above their level, so that the weight is carried by the brickwork alone without pressing on the joists. Bond plates should be avoided, as in most cases they are a source of weakness to the wall, and generally decay before the wall or the joists; broad and stout iron bond laid on the course below the joists is much more durable and secure. No timbers should be placed beneath or in near proximity to a fire hearth, or to a smoke flue. Nine inches of solid brickwork should always intervene.—AUBERY.

ADVANCED REPLIES.

QUESTION 1. *What means for the preservation of timber are recommended?*—Presuming the timber has been felled at the proper time and stacked with care, and is delivered in a good state ready for the builder, the means employed to preserve it are various, and must depend in a great measure upon the nature of the work for which it is to be employed. For instance, if it is for external work of a common character, the best preservative is to well paint it, and, while still wet, strew it with sand, and, as soon as the paint has perished, repaint it. For posts and piles exposed to the action of moisture in a great degree, the best means is to char the wood, as it then in a great measure becomes incorruptible. Semple advises scorching the wood all over, and, while still hot, rubbing it with linseed oil and tar; the scorching can be effected by passing over the timber a powerful flame produced by coal gas and a blow-pipe. As a preservative against worms nothing can be done better than to saturate the wood with any of the oils. As to the patent methods for the preservation of timber, there is one by Kyan, patented in 1832, which consists in impregnating the timber with corrosive sublimate, and another of a similar kind patented by Payne in 1841. The best preservative for timber I can recommend is (after having obtained the best seasoned, and when worked for the various purposes required), for it to be well rubbed with oil, and, when framing it in its place in the carcase of the building, taking care to keep it as much as possible from the masonry, and allowing the circulation of plenty of air without being liable to action of the weather, and, when the carcase is complete, allowing it to stand as long as possible before the timbers are covered in, so that they may have, as it were, a second seasoning.—H. R. P.

QUESTION 2. *What are "wet" and "dry" rots? State what preventive means may be adopted.*—Wet and dry rots are two forms of decay which attack timbers exposed to the action of the weather, and the cause of both may be said to be heat with moisture. Confined air and evaporation cause dry rot, and imperfect evaporation wet rot. As a preventive against these rots the timbers should be well seasoned, and, if used where liable to be under the influence of sun and rain, should be well painted. If not painted they may be impregnated with linseed or oil of tar; but the best preventive is to allow a free circulation of air around the timbers, and the walls to be allowed to dry thoroughly before the introduction of the timbers. Should the timbers have taken either of these rots very little can be done to preserve them. If the rot is perceived to be at the ends of beams only—and here it generally commences—the best way to preserve the rest of the timbers would be to cut away the decayed portion and scarf with sound. Should this not be practicable, the wood should be scraped and cleaned of all fungous or extraneous matter and then impregnated with any of the oils, or some of the patent methods referred to in the answer to last question may be tried.—H. R. P.

[No satisfactory reply to the last question to hand.]

METALLIKON.

WE have seen some specimens of a new material recently introduced for use in architectural decoration, called "Metallikon" or the "Inseparable French Crystal," which possesses many advantages, and seems capable of almost indefinite adaptation. The invention consists in the combination of glass and ceramic substances, either singly or combined, in a manner quite novel and very ingenious. For instance, the inventor produces stained glass windows ornamented with designs of any required character, by means of glass or ceramics in various forms and colors placed upon a sheet of colorless glass and fastened thereto by means of a transparent cement, thus entirely obviating any interference with the general design. Sometimes rods, tubes, or prisms of glass are used with increased brilliancy of effect. The idea is also applied to the encasing of any architectural features admitting of ornamentation, such as consoles, trusses, or brackets, as well as panels, and the surfaces of walls generally. Upon flat surfaces the inventor prefers to lay a ground of silvered glass or other suitable decorative material, and to place thereupon glass, rods, tubes, or prisms, arranged either in single or double layers, the latter to be arranged at right angles or obliquely to each other so as to produce a figured character, the result of the refracted light. Tiles can also be made by several methods on the same principle (a surface decoration of very great beauty, and perfectly proof against all atmospheric influences). Various other uses have suggested themselves for the new material. It can be made into fire screens, window blinds, venetian blinds, and a variety of other useful and ornamental articles, in every case with satisfactory results so far as economy is concerned.—*Building News.*

LARGE SPAN STATION ROOFS.

AMONG the most recent examples of large span railway station roofs are two in course of construction at Glasgow and Manchester. The Glasgow roof is to cover the large new station at St. Enoch Square for the Glasgow Union Railway. This roof, which is well advanced towards completion, is of the same general character as that of the St. Pancras Station, London, but smaller, the Glasgow roof having a span of 198 ft., and a length of 518 ft., as against a span of 240 ft. and a length of 689 ft. in the Midland roof. The new roof will be 90 ft. high from platform level, and will be supported by 15 main ribs, 12 of which have already been erected in place, and the ironwork for the remaining three is being sent forward. The total weight of the ironwork in this roof is about 1400 tons. The engineer who designed it was the late Mr. Blair, and the contractors are Messrs. Handyside & Co., of Derby and London. The roof at Manchester is for the new joint station of the Midland, the Great Northern, and the Manchester, Sheffield, and Lincolnshire Railways, and the works have recently been commenced. The design is also of the same character as that of the St. Pancras roof, the span being 210 ft. and the length 550 ft. The cast and wrought iron will weigh upwards of 2300 tons, of which nearly the whole will be in the roof itself. The contractors are also Messrs. Handyside & Co., and the work of construction is being carried out by Mr. Charles Sacré, the engineer of the Manchester, Sheffield, and Lincolnshire Railway.—*Building News.*

A NEW SYSTEM OF PLASTERING.

BUILDERS, owners and tenants of city houses will doubtless view with interest a new system of plastering, which is is said will prevent the sudden and disastrous downfall of ceilings, so frequently occasioned by defects in the water-pipes, and consequent leakage and overflow. The invention consists of replacing the scratch coat and brown coat used in ordinary work, by the combination of fibro-ligneous sheets with a cement composed of lime, sand, and plaster. The sheets are of a fabric resembling coarse bagging, which is secured to the lathing, and the cement is supplied in the ordinary way. A hard-finish coating completes the work.

A FALL of meteoric stones took place near Ställdalen, in Sweden, June 28, between 11 and 12 A.M. Twelve fragments have been found, one of which weighs 4½ lbs. A spectator affirms that a very intense whistling was heard, accompanied by a light which was very distinct, though the day was clear and cloudless. Two very loud explosions were heard, succeeded by one less violent, after which eight or ten persons saw the meteorites fall.

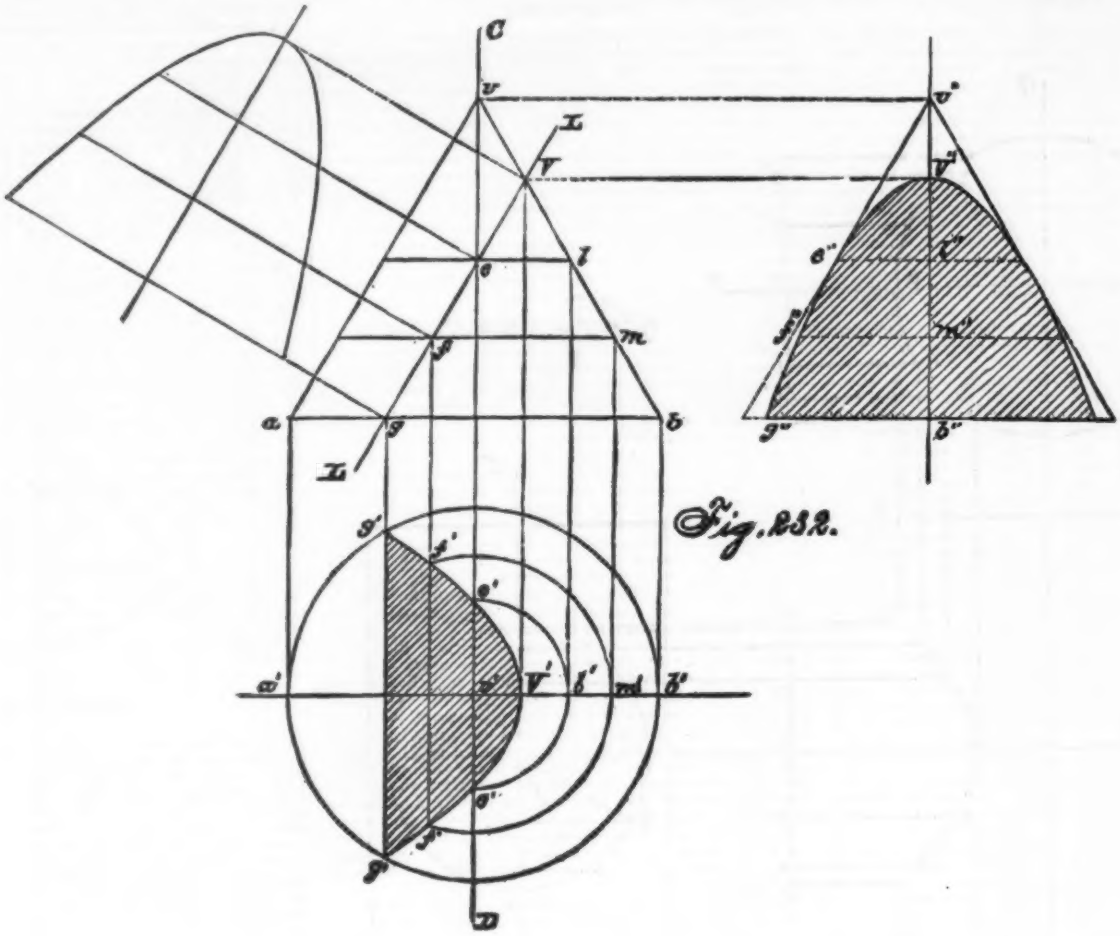


Fig. 232.

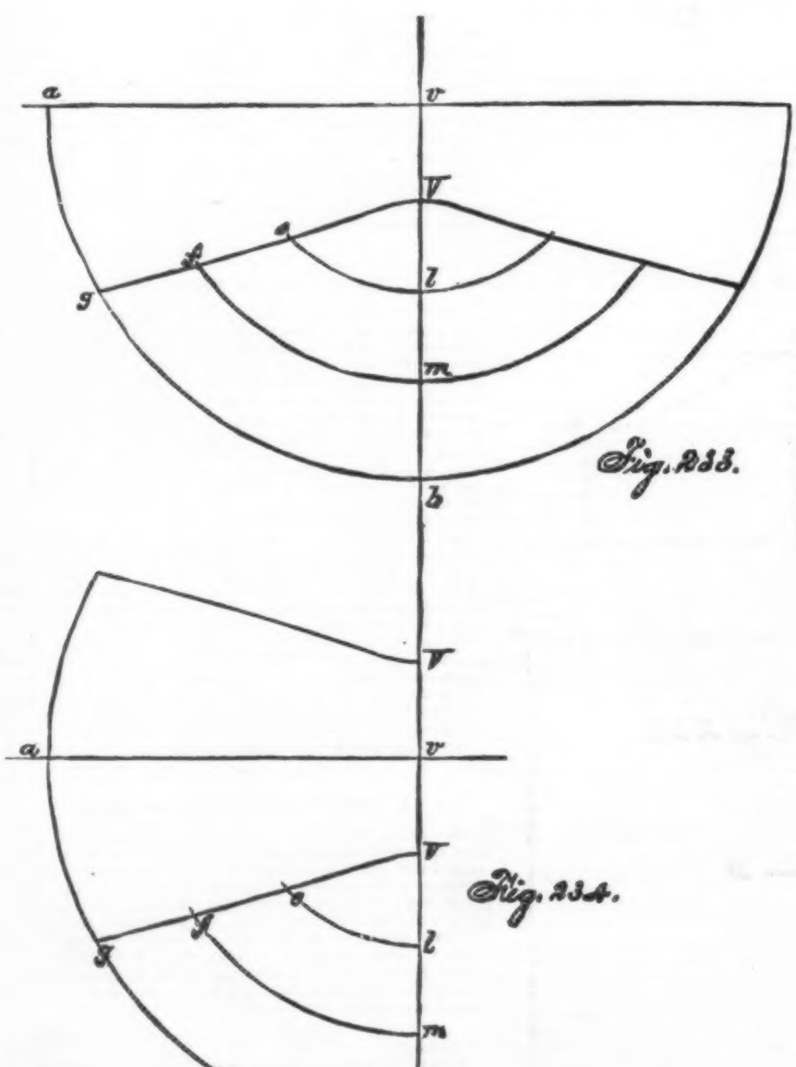


Fig. 233.

Fig. 234.

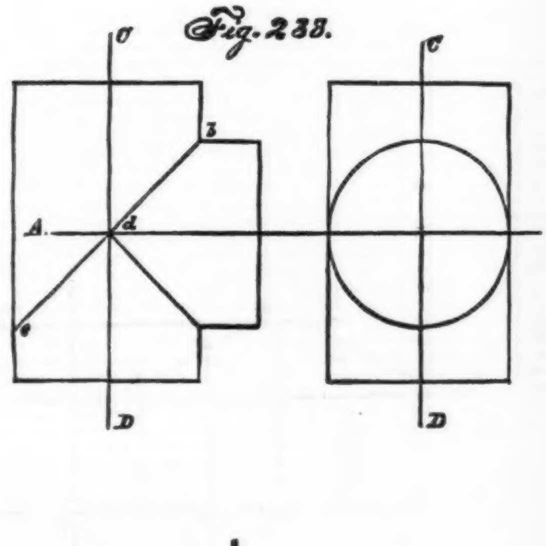


Fig. 238.

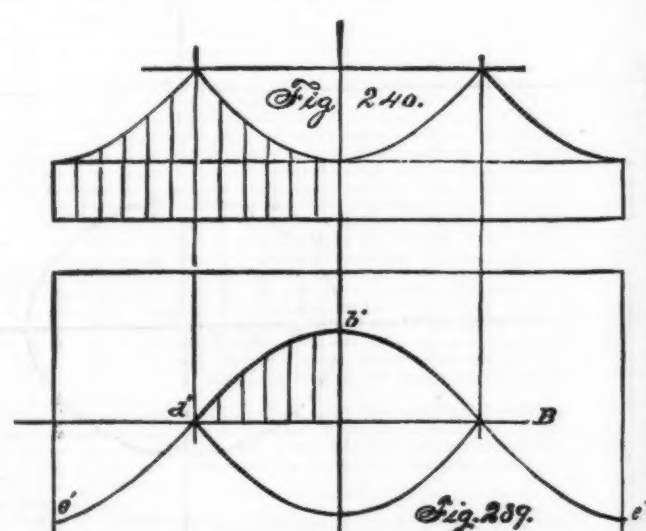


Fig. 240.

Fig. 239.

LESSONS IN MECHANICAL DRAWING.—No. 27.

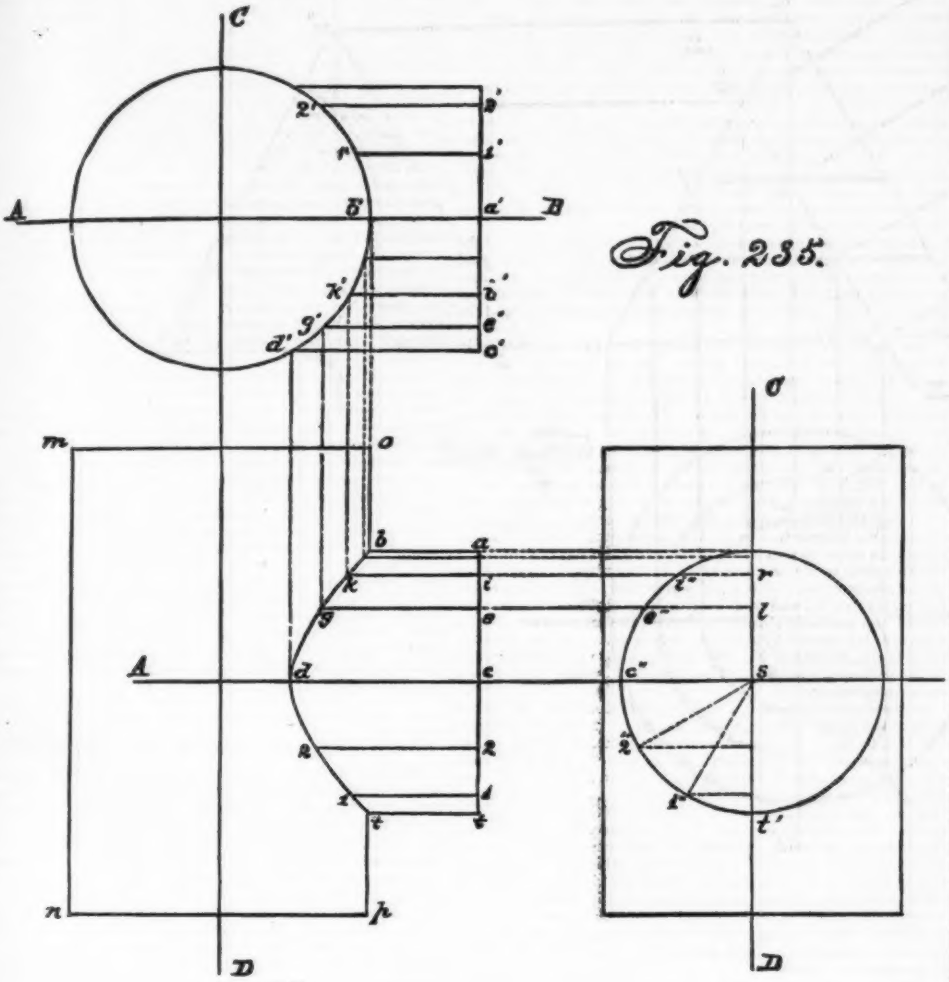


Fig. 235.

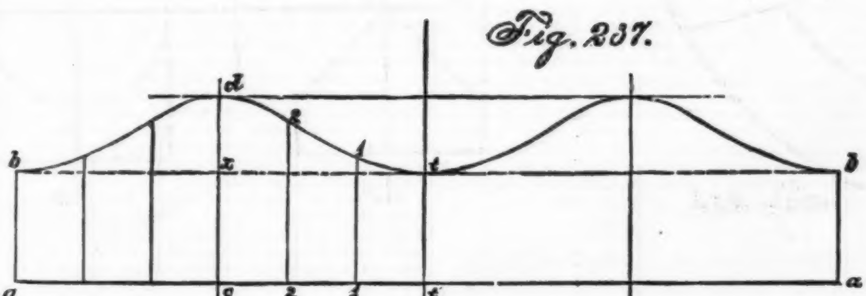


Fig. 237.

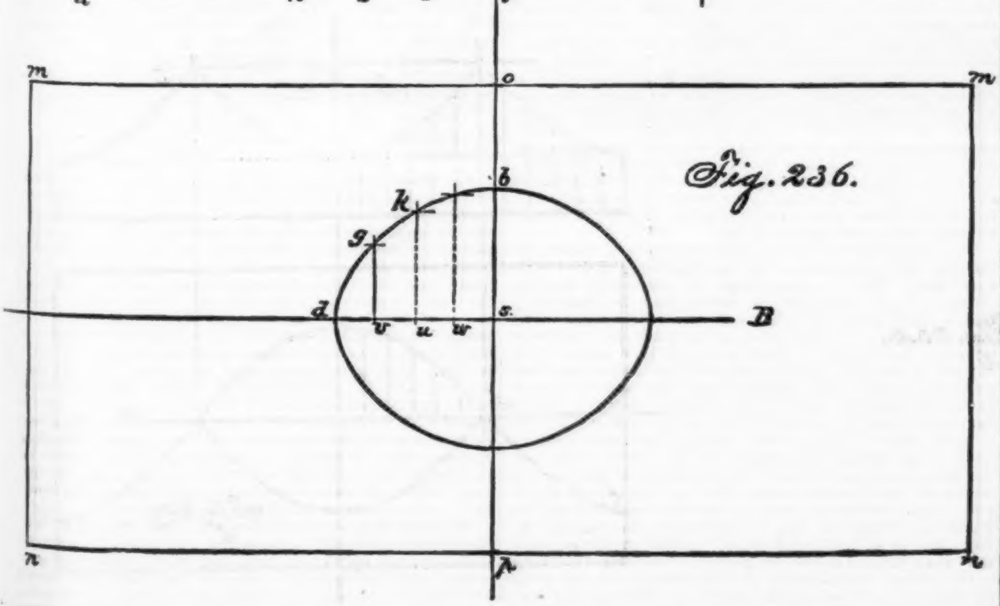


Fig. 236.

LESSONS IN MECHANICAL DRAWING.—No. 27.

LESSONS IN MECHANICAL DRAWING.

By Prof. C. W. MacCord.

No. XXVII.

In Fig. 232 we have again a cone cut by a plane, seen edgewise in the front view as the line L L; which, however, is in this case parallel to the extreme visible element, or outline of the cone, *a v*. Presuming that the student can, if he likes, make the construction by the method of drawing rectilinear elements cut by the plane, without assistance, we shall now consider only the mode of finding the form of the section, dependent on the use of a system of horizontal planes, as explained in connection with Fig. 227. This method is here slightly modified, at least in one particular, which is that these different circles are not cut in the same vertical line, as they were before, just because the plane is inclined. The base of the cone appears in the front view as the line *a b*, which intersects L L at *g*; and the student will readily perceive on reflection that as the intersection of two planes is a right line, this point *g* will be the projection of a line perpendicular to the plane of the paper in that view, and appearing in its true length as $g'\ g'$ in the top view. So also with the horizontal plane through *m*; it intersects the inclined plane in a line of which, in the front view, we see only the end *f*, but in the top view we see the true length of the whole line, $f'\ f'$.

Which may also be regarded in a slightly different manner, thus: If through any point as *l* on the surface, we draw a circle, it will run round the cone, its plane being parallel to that of the base and therefore horizontal. This circle will appear in the top view in its true form, its radius being $v'\ l'$; and its circumference will be cut by the plane L L, as seen in the front view, in two points at the same distance to the left of *l*, and as they are also at the same height, one will be directly in front of the other. These must in the top view appear vertically under *e*, their position in the front view, and also on the circle through l', as shown, and the right line joining them will be a chord of this circle, $e'\ e'$.

The construction of the side view, shown on the right, and also of the true form of the section, looking perpendicularly against the plane L L, as shown in the inclined view at the left, should require no explanation, the processes being identical with those previously described in connection with the other conic sections. The same might be said in regard to the development, given in Fig. 233, in which *v b* is the slant height, the arc *a b a* equal to the circumference of the base, the arc *b g* equal to the arc $b'\ g'$ of the top view, *v m* equal to *v m* of the front view, the arc *m f* equal to the arc $m'\ f'$ of the top view, and so on. In this figure the cone is supposed to be cut along the element *a v*, for the purpose of showing the full form of the developed section as a continuous line; but were it intended to make a model in sheet metal, it should, as stated in the preceding lesson, be cut along the opposite element *b v*, in which case the remaining portion, which when wrapped up is to form the part of the cone on the left of L L in the front view, will develop into the outline shown in full lines in Fig. 234.

Another class of problems continually arising in practice, consists of those relating to the intersections, or as they are sometimes called, interpenetrations of surfaces; for example, a cylindrical pipe with a cylindrical nozzle, or side pipe, entering it. Problems of this nature are met with in all kinds of work—in castings and finished forgings as well as in sheet-metal work; and the variety of forms given, according to circumstances, to the surfaces which intersect each other is so great, that it would be impossible to illustrate in detail any more than a small proportion of them. We shall, therefore, select such examples as are most frequently met with, and endeavor to explain the principles which are involved in determining the forms of the intersections in such a manner that the student will be able to apply them subsequently for himself, and to devise some means of solving any problem of the kind with which he may meet. Probably it may occur to him, but if not we will state it, that the general feature which will lead to a solution is essentially the same as that involved in the preceding cases, in which one of the intersecting surfaces is a plane. In those, we drew lines upon the surface which was not a plane, in such a way that we could find the points in which the plane cut those lines, and these points lay on the line of the section sought. Extending this a little, we see that if we draw a line on one surface, it will be cut by the other, if at all, in a point which lies on both, and is therefore on the required line of intersection. From this point we can draw another line on the other surface; consequently if we draw two lines, one on each surface, and they cut each other, the point thus located will lie on the line sought.

The first example which we give is that in which two cylinders intersect each other, the diameters being unequal and the axes meeting at right angles. Thus in Fig. 235, let C D be the axis of the larger, A B that of the smaller. For convenience, the cylinders are placed in the simplest relation to the paper—that is, so that the axes are parallel to it in the front view and in the side view. Under these circumstances, it is clear that the horizontal line *a b* on the top of the smaller cylinder will intersect the vertical line *o b* at the extreme right of the larger one, at the point *b*, which, therefore, is one point in the line sought. And the line *c d*, which in the top view appears as $c'\ d'$, as clearly meets the larger cylinder in the point d' of the top view, whence the point *d* in the front view is determined by simply projecting a' on A B of the latter view, in which it must be perpendicularly under d'.

Now, to find another point in the line, we proceed thus: If we take any point as e'', in the side view, on the circumference of the circular base of the horizontal cylinder as there seen, it will correspond to a horizontal line *e g* on the same level in the front view. The top view of this line will be found by setting off $a'\ e'$, equal to $c''\ l$ in the side view, and drawing $e'\ g'$ parallel to the axis of the smaller cylinder, and this line will pierce the larger cylinder at the point seen in the top view as g', and in the front view as *g*. Similarly we set off $a'\ i'$ equal to $r\ i''$, draw $i'\ k'$, and from k' drop a perpendicular on *i k* the front view of $i'\ k'$, thus determining *k*, another point in the curve required, and so on for as many points as we please.

Considering the top view, we observe that the lines $i'\ k'$, $e'\ g'$ increase in length as they recede from the axis A B; and $c'\ d'$, the element of the horizontal cylinder nearest us, is the longest of them all. Therefore, the curve can go no further to the left than *d*, and as the cylinder is cut in half by the horizontal plane, the lower part *d t* will be precisely like the upper part *d b*.

We have, then, the required line of intersection; and if the cylinders be solid, or supposed to be of cast metal, so that a mere representation is all that is wanted, there is no more to be done. But if, on the other hand, we wish them to be made of sheet metal, it is necessary to develop each of them

separately; so that in the case of the larger one we may find the shape and size of the hole that is to be made, in order that when the metal is formed up the smaller one will fit it; and in the case of the smaller one, that we may know the form of the piece which will fit that hole when both are rolled up and put together.

First, then, let us suppose the vertical cylinder to be cut along the left-hand element $m n$, and unrolled; laying it down so that the right-hand element, $o p$, shall coincide with $o p$ of Fig. 236, the shell will assume the form of the rectangle $m m n n$. The highest point b, and the lowest point t, of the opening in this shell, will remain on the line $o p$. The point d will appear in the development on the same level as before, but at a distance to the left of $o p$ equal to the length of the arc $b' d'$. So the point g in this development will appear on the same level as in the front or the side view, but at a distance $l g$ from $o p$ equal to the rectification of the arc $b' g'$ in the top view. And the point k will be found in the development on the same level as in the front view, its distance from $o p$ being the length of the arc $b' k'$; and so of any other point in the curve of intersection.

The position of the points in the front, side, or top view, of which we thus make use in determining the form of the developed curve, is theoretically of no consequence. And the same is true in regard to the points made use of in determining the curve before development; the principle of construction is perfectly general, and we are at liberty to select any points that seem best, in accordance with the conditions above set forth. But in practice it does make a material difference whether we select one set of points or another, if the intention be to construct the development ultimately. And the student is advised to pay particular attention to this circumstance, since the mode of proceeding here illustrated may serve to suggest to him the means of saving much time and labor in future operations.

In the first place, then, the extreme length of the developed opening in the vertical cylinder, in Fig. 236, is twice that of the arc $b' d'$ in the top view of Fig. 235, as above stated; and in order to obtain it we must rectify that arc by the means before described. After that, it will be seen that if the points g', k', etc., be taken at random in the top view, it will be necessary to rectify separately the arcs $b' g'$, $b' k'$, in order to find how far to the left of $o p$ in the development these points will appear.

But if $b' d'$ be divided into equal parts at the points g', k', etc., this labor will be saved, since we need only divide $s d$ of Fig. 236 into the same number of equal parts at the points v, u, etc., in order to have these distances from $o p$ correctly laid out.

Now, it will be seen that the curve of intersection in the front view can be drawn just as easily by the aid of the points k', g', etc., whether they divide the arc $b' d'$ into equal parts or not; consequently, if the drawing be intended for the use of the worker in sheet metal, it will be advisable at the very beginning to divide $b' d'$ into some convenient number of equal parts, and to make use of the lines and points thus determined, in constructing, as well as in developing, the curve of intersection. The principle of operation is not affected in the least; but simple as is the process of rectifying the arc by the method given, it nevertheless takes more time than it does to subdivide an arc and a line. It is, of course, impossible to lay down stated rules for reducing the labor involved in constructing a given problem to a minimum; the most that we can do is to point out from time to time, as examples occur, such time-saving expedients as have been suggested by experience, in the hope that the reader may profit by them, not merely by adopting them in similar cases, but by forming the habit of seeking for others, and of finding them too in time of need.

The development of the horizontal cylinder is given in Fig. 237; it is supposed to be cut along the upper element $a b$, and the circumference of the right-hand end becoming the right line $a a$, we set up at each extremity the ordinates of the length of that element; and at the centre of the length $a a$, another ordinate equal to $a b$, corresponding to the lower element $t t$ of the horizontal cylinder.

Now, $c d$ is midway between $a b$ and $t t$, as well after as before development: bisecting $a t$ then, in Fig. 237, we set up another ordinate equal to $c d$ of Fig. 235, the idea being, here as in the other operations of development, that neither the lengths of, nor the actual linear distances between, the elements of a surface are changed by unrolling it.

We may then select these elements at random, without affecting the result; but it will be, of course, better in practice to proceed systematically in this case too. If, for example, we have, as above recommended, divided $b' d'$ into equal parts with a view to the ready development of the hole to be cut in the larger cylinder, it will be seen that when the points i', e', etc., thus determined are transferred to their corresponding positions, i'', e'', etc., in the side view, Fig. 235, the divisions $a'' i''$, $i'' e''$, etc., of the circle in that view will be unequal, which will necessitate the separate rectification of a number of arcs. It will then be better to subdivide one of the quadrants of this circle, as $c'' t''$, into equal parts, as, for example, at the points $1''$, $2''$; if we then set off the distances of these points to the left of the axis, in the top view, as shown at $1'$, $2'$, and draw the elements $1' 1'$, $2' 2'$, through the points thus determined, we have only to divide $t c$ in the development in a similar manner, and erect ordinates at the points of division of lengths equal to those of the corresponding elements just drawn. In this way we find the curve $t\ 1\ 2\ d$: this is the development of one quadrant of the line of intersection, and as it is clear that the other quadrants are exactly similar and equal to this one, we have only to copy this curve three times, to complete the upper outline of the shell as in the figure.

In regard to the form of this outline, it will be observed that either half of it, as $b d t$, has a resemblance to the sinuous curve obtained by developing the surface of a cylinder cut by a plane inclined to the axis, as shown in Figs. 212 and 215.

It is not, however, the same, for the very reason that neither cylinder is cut by a plane; neither $b' d'$ in the top view, nor $b d$ in the front view, is a right line. But the curve has two horizontal tangents, at its highest and lowest points, as shown, the vertical distance $d x$ between them being, of course, the difference between the lengths of the longest and shortest elements, $c d$ and $a b$.

In reference to the developed opening, as shown in Fig. 326, it is to be noted that it will have a horizontal tangent at both top and bottom, and a vertical tangent at each end. For it can be proved, as will subsequently be shown, by a course of reasoning involving principles not yet discussed, that in the front view of Fig. 235 the curve of intersection will have a tangent at b, perpendicular to the paper, and that the vertical element is tangent to it at d. The first one will be horizontal, and will come into the plane of the paper in Fig. 236, and the second does not change its position, and neither of them change their relation of tangency to the curve during the development.

But though under the conditions here assumed this is true, there is an exceptional case, which is illustrated in Fig. 238. The two cylinders are here of the same diameter; and, in consequence of this, the line of intersection $b d$ is not curved in the front view, but straight, and makes an angle of 45° with both the horizontal and the vertical axes, the point d falling at the intersection of C D and A B as there projected, but in fact lying of course in front of the actual intersection of the axes, as shown at d'' in the side view. Since there is obviously another line directly behind $b d$ on the farther side of the cylinders, it follows that the line of intersection of these two surfaces is the same as though they were cut, above the horizontal axis, by a plane $b e$, seen edgewise in the front view. This the student can readily verify by constructing the intersection in the manner before adopted; and the lower half of the curve being symmetrical with the other, will be the same as though another plane were drawn at the same inclination in the opposite direction.

The actual line of intersection then in this case will not be a continuous curve, but will consist of two similar and equal plane curves intersecting each other, at d and the point diametrically behind it; each of them will have of course tangents at those points, but the vertical elements will not be tangent to either.

And in the development, the aperture will be symmetrically divided by the horizontal centre line, as shown; but the upper and lower branches will intersect each other on that line, so that the opening will be pointed instead of rounded at the ends, as shown in the figure. We do not give the steps of the construction, which is left as an exercise for the student. However, it is not a new one, for the reason above pointed out, that the intersection is the same as that shown in Fig. 212, if we imagine the plane $b d$ to be continued to e; which we mention again, because it is a good thing in constructing the development, Fig. 239, to continue the curve beyond its intersection with the horizontal centre line, as shown, in order to make sure that it has the right direction: the complete curve of the section by the plane $b e$ appearing as the sinuous line $e' d' b' e'$, of which the part $e' d'$ is similar and equal to $d' b'$, and the half on the right of the vertical centre line precisely similar to that on the left. The student may also lay out for himself the development of the horizontal cylinder, shown in Fig. 240, in which also the intersections of the different branches of the curve will make their existence conspicuous.

In these developments, it will be understood that the thickness of the metal is disregarded, as indeed it may be in practice if it be small in proportion to the diameters of the cylinders, cones, or other surfaces to be made. It will be seen also that no allowance is made for "lap" to form a joint, but that the sheet when cut out is supposed to be rolled up so that the edges shall just come together, without overlapping at all. The consideration of such overlapping, in order to facilitate the fastening, whether by soldering or riveting, is an independent practical consideration, which we have purposely kept out of view, for the reason that it has nothing to do with the principles or methods involved in making the development; and it is to these that we wish at present to give undivided attention, and this is best accomplished by leaving out of the question the thickness of the material and the mode of securing the joints.

Finally, we call attention to the arrangement of the different views included in each group, which is such as we would recommend were these drawings intended for actual use in the shop. For instance, Figs. 235, 236, 237, form a complete "working drawing," by which a tin model of the object represented could be made. It will be understood of course that the "construction lines," and the guiding lines which we have dotted in for the purpose of aiding in our explanation, would be omitted: it is the draughtsman's business to solve the problem, and his drawing must when completed show the results, but it need not show the steps. The responsibility rests upon him, and the mechanic has only to follow the drawing. We do not mean to say that the "original drawings," which are kept in the drawing office, should never contain any clue to the steps of construction, or record of them; on the contrary, as we shall have occasion to show, they very frequently not only may but should preserve such a record, which may afterward greatly facilitate the reading of the plans. But usually these "originals" are not sent into the shop, but copies or tracings are made for that purpose, in which these things may be omitted. But the centre lines which we have drawn here ought to be drawn in such copies as well as in the originals; and it will be well also to give a series of ordinates, as in Figs. 239 and 240, for the purpose of aiding the mechanic in copying the curves.

UTILIZATION OF WASTE IRON.

WILLIAM BATTY, Philadelphia, has invented a process by which partly decarbonized iron, such as stove and machinery scrap, and the harder numbers of pig iron, 2, 3 and 4, can be melted and made softer, or carbonized to such an extent in melting as to take the place of No. 1 pig for all kinds of castings. By this process any old stove can be made at one melting into a new one; an old tin roof may be transformed into any kind of cast-iron article, and clippings of tin and other tin refuse can be utilized in making castings. The inventor claims to be able to melt iron waste of every description, and produce therefrom castings of any desired quality, by modifying certain details and varying the duration of the operation, the rapidity of which—that is, the productive capacity of the cupola—he claims to have doubled, while effecting a decided economy in the consumption of fuel.

The essential part of the process seems to be to recarbonize the iron which always loses carbon when being melted in the usual way. This is accomplished by introducing into the furnace a larger proportion of carbon than is contained in coal, in such a way as to combine with the oxygen of the blast. This is done by dropping in the blast pipe, just before it enters the tuyeres, a finely-powdered pure carbon. The oxygen of the blast commingling with the carbon, they both strike the melting zone together, and each atom of oxygen having an atom of carbon with which to unite, a neutral flame is obtained, in which the heat is very intense. The iron is made better, melting more rapidly, and there being no oxygen whatever left to combine with the carbon in the iron, but rather an excess of carbon being present, the iron becomes carbonized, and therefore softer after melting than it was before, a result entirely contrary to that now obtained by iron founders. Where the iron is very much decarbonized, Mr. Batty uses as an auxiliary a bed of charcoal in the bottom of the cupola-furnace below the tuyeres. The slag that forms in the furnace lies between the tuyeres and the top of the charcoal bed, and prevents the latter from burning out, while the molten iron circulates through the charcoal and takes up such a quantity of carbon as will refine, purify, and soften the cast iron.—*The Bulletin.*

WHAT IS PHOSPHORESCENCE?

THE phenomenon of phosphorescence has often troubled the chemist and the photographer, and there are no doubt among our readers some who have, at one time or another, endeavored to obtain reflections of phosphorescence upon the photographic film. We have never heard of the attempt proving successful, for the luminosity given off is, after all, so faint that such a result is hardly to be expected. We see that a German philosopher has recently been directing his attention to phosphorescence, not from a photographic point of view, however, but in order to discover, if possible, the true cause of the remarkable phenomenon. The result of his investigation is that he is enabled to confirm the conclusions arrived at by others—such as Hulme, Placidus, Heinrich—who have worked in the same direction. The simplest mode, so it appears, of bringing about phosphorescence is to place marine fish in a three per cent solution of salt, and, according to M. Pflüger, the phenomenon may be observed the second evening. The luminosity, M. Pflüger tells us, begins in the eyes, and thence spreads all over the fish, increasing in intensity from day to day, its duration depending upon the temperature. The luminosity is of such a nature that the fish appears, after a time, to be luminous all through; but this is not the case, for, on scraping off the surface, it is quite black underneath. The luminous matter is, indeed, a kind of slime, which is perfectly apparent in daylight, when it is of a dirty-white color; it is only in the dark that it shines with a phosphorescent lustre. It appears that any animal matter may be rendered phosphorescent by applying to the surface some of this slime, or, in other words, can be infected by the slime. M. Pflüger has examined the slime under a microscope, and it was found to contain a mass of schizomycetes, which, from the fact that they moved actively about, were doubtless alive. Hence he concludes that the small living cells of the schizomycetes are the luminous agents. The animalculæ, he points out, are not so small that they can not be filtered from any water in which they may happen to be. M. Pflüger, in his paper, proceeds to give the results of investigation of other decaying matter in which phosphorescence is observed; but we need merely quote the summing-up of his conclusions in respect to this mysterious question—namely, "all phosphorescence of decaying organisms is the luminous respiration of living parasites."—*Photographic News.*

ENAMELLING OR GLAZING OF PHOTOGRAPHS.

THE first thing to be done is to procure, as stock in trade, one or more smooth, thick plates of glass. In making a selection avoid those having surface defects, such defects being reproduced on the picture. A plate of this description having been very carefully cleaned and made quite dry, a thin film of wax is applied. This may be done either by warming the plate and rubbing over it a piece of white wax, or by dissolving the wax in ether or any other convenient solvent and pouring a little upon the surface of the plate, distributing it with a clean cloth. Such an amount of friction must be applied as will effect the removal of the superfluous wax. It should be borne in mind that the more perfectly the wax is removed—short, however, of its total removal—the better will be found to be the polish of the finished print at a subsequent stage. The method adopted by several French operators of preparing the surface in order to prevent the adhesion of the collodion is that which, so far as we recollect, was first recommended by Mr. W. B. Woodbury—namely, sprinkling a little finely powdered talc or French chalk over the surface and thoroughly rubbing it all over the plate.

The surface of the glass plate having been prepared in the foregoing manner, a coating of plain collodion is next given. The collodion used for this purpose should be of a hard, tough, skinny character. Upon this collodion coating is applied another of gelatine. This latter is composed of an ounce of gelatine placed in twelve ounces of water. Allow the gelatine to soak in the water for an hour or two, and then immerse the vessel containing them in another of hot water, by which the gelatine will rapidly become liquefied. If the gelatine be of an opaque kind it is advisable to stir up with it, when at a temperature of 80° or 90° Fahr., a little albumen, and then subject the whole to such a degree of heat as will coagulate the albumen, which will then separate from the gelatine, leaving the latter very limpid and pure. To effect this separation it is often necessary to have recourse to straining through a piece of muslin.

The original suggestion of Mr. Tunny, to coat plates of large dimensions so as to lay down upon one of them, and thus glaze, a number of prints at one operation, is universally acted upon at the present period by all who carry out the process on a large scale. Of course we need scarcely observe that the larger the plates the thicker and stronger must they be proportionately. When the process was first published, in 1864, we prepared two or three dozen plates and kept them in a plate-box ready for use when occasion demanded.

A method practised in Paris with success is to mix a little glycerine with the gelatine. The proportions adopted by one successful operator are:

Gelatine	1 ounce.
Glycerine	2 drachms.
Water	10 ounces.

The prints to be glazed are plunged into water for about half a minute, and, after having the superfluous moisture removed by blotting paper, a little of the warm gelatine solution is applied to the faces by brushing it well over every portion of the surface. Allow the picture to become dry. Next pass a wet sponge over the gelatinized surface of the glass plate until it is all evenly wetted, and then immerse the print in water for a few seconds. Now, having placed the print, face down, upon the glass plate, press it in very intimate contact with the surface by means of a squeegee or other similar contrivance, taking great care that no air-bubbles be left. This is very easily seen by turning over the plate and looking at the print through the glass. When the whole of the prints have been treated in this manner the plate is placed aside for ten or twelve hours to dry. The drying may be facilitated by the application of a very gentle heat and a current of air. A sharp knife must next be run round the margins of the prints, and by lifting up one corner the pictures will come away from the glass with the greatest facility, their surfaces being very fine and glossy.

We know of several operators who, after coating the surface of the glass with gelatine, do not allow it to become quite dry, but only to set well, afterwards immersing it in water; and they apply the prints to the glass after giving the former a coating of gelatine, and without allowing the latter time to set. We have in our possession prints enamelled by both methods, but are unable to discover any difference between them.—*British Journal of Photography.*

ENAMELLED COOKING VESSELS.

AT the country meeting of the Society of Public Analysts held in Glasgow, during the recent visit of the British Association, a paper was read by Mr. Robert R. Tatlock, F.R.S.E., F.C.S., Glasgow, on "Enamelled Cooking Vessels." He stated that in some instances the milk white porcelainous enamel, with which cast-iron cooking vessels are now so commonly prepared, is of such a character as to be objectionable in the highest degree on account of the easy action upon it of acid fruits, common salt and other ordinary dietetic substances, by means of which lead and even arsenic are dissolved out in large quantity during cooking operations. The following analyses were given of three enamels, the samples having been taken from three cast-iron pots made by different manufacturers:

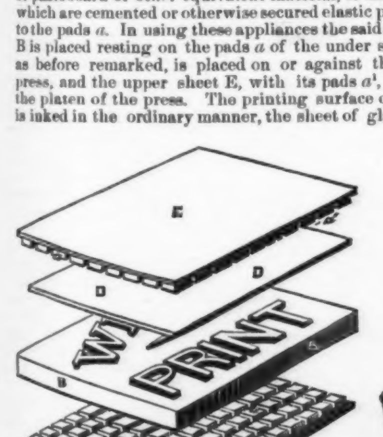
	No. 1. Per cent.	No. 2. Per cent.	No. 3. Per cent.
Silica	61.00	42.40	42.00
Alumina	8.00	2.88	6.06
Oxide of iron	1.10	2.04	4.04
Lime	3.02	0.16	0.78
Magnesia	0.28	0.10	0.21
Oxide of lead	absent	25.89	18.48
Potash	5.61	7.99	6.46
Soda	20.67	14.67	19.25
Phosphoric acid	trace	trace	trace
Arsenious acid	0.02	0.42	1.02
Carbonic acid	0.30	absent	absent
Borax	absent	3.45	1.70
	100.00	100.00	100.00
Total bases	38.58	53.73	55.28

The author showed that it was not so much on account of the presence of large proportions of lead and arsenic that the enamels are so objectionable, but because they are so highly basic in their character that they are readily acted upon by feebly acid solutions, the lead and arsenic being thereby easily dissolved out. He showed that the ratio of the bases to the silica in the No. 1 was as 1 to 1.58; in the No. 2 as 1 to 0.79; and in the No. 3 as 1 to 0.76. A 1 per cent solution of citric acid boiled in the No. 1 did not affect it in the slightest, while in the case of the No. 3, the glassy surface of the enamel was at once roughened and destroyed, and lead dissolved out to such an extent as to give immediately a dense black precipitate with sulphuretted hydrogen. He thought that no enamel should be admitted to use unless it was totally unaffected by boiling with a 1 per cent solution of citric acid, which was a very moderate test, and gave it as his opinion that either the use of such poisonous ingredients as lead and arsenic in large quantity should be entirely discontinued, or that the composition otherwise should be of such a character as to insure that none of the poisonous substances could be dissolved out in the circumstances under which the vessels are used.

PRINTING ON GLASS.

By J. L. WELLS, Philadelphia, Pa.

CONSISTS in placing on or against the bed of the printing press a flat sheet, A, of pasteboard or other suitable material, upon the upper surface of which are secured a series of small elastic pads, a, by preference made of rubber of a quadrangular shape and arranged in rows a short distance apart; and in using a flat printing block, B, which may be made of wood mounted with such letters, figures, or ornamental characters in relief as the design to be printed on the glass may require, the printing surfaces being made preferably of rubber or of other equivalent elastic material; and in using an upper sheet, E, of pasteboard or other equivalent material, to the under side of which are cemented or otherwise secured elastic pads, a^1, similar to the pads a. In using these appliances the said printing block B is placed resting on the pads a of the under sheet A, which, as before remarked, is placed on or against the bed of the press, and the upper sheet E, with its pads a^1, is attached to the platen of the press. The printing surface of the block B is inked in the ordinary manner, the sheet of glass D is placed upon it; the platen is applied with the requisite pressure, and thus and by these means the object of the invention is effected. Between the plate of glass D and the pads a^1 of the upper sheet E may be interposed a sheet or sheets of thin paper. Any ordinary printing press may be used.



PRINTING ON GLASS.

IMPROVEMENT IN PHOTOGRAPHIC-CAMERA LENSES.

By ADOLPH STEINHEIL and EDWARD STEINHEIL, of Munich, Bavaria.

ALL the best photographic lenses, as heretofore constructed and used, consist of three lenses arranged separately, a method of construction which causes fifteen reflected images—a result most injurious to the photographic image or picture produced, inasmuch as the light becomes considerably troubled or disturbed.

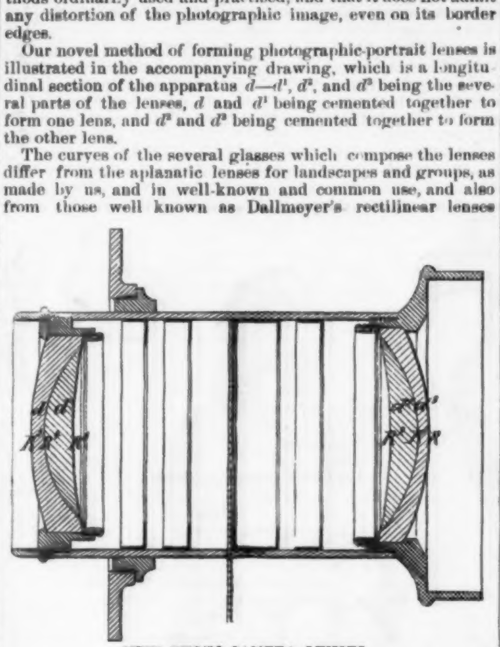
Our invention consists of a novel form and adjustment of the apparatus, by which two lenses only are used, each of which lenses consists of two parts cemented together.

By this method of construction and arrangement greater simplicity is obtained, and only six reflected images are produced, and the resulting photographic image or picture is less injured by the disturbance of the light.

The most essential advantages, however, arising from our novel method of forming and constructing the apparatus consist in the much greater speed with which it operates, as compared with the best and clearest lenses constructed in the methods ordinarily used and practised, and that it does not admit any distortion of the photographic image, even on its border edges.

Our novel method of forming photographic-portrait lenses is illustrated in the accompanying drawing, which is a longitudinal section of the apparatus d—d^1, d^2, and d^3 being the several parts of the lenses, d and d^1 being cemented together to form one lens, and d^2 and d^3 being cemented together to form the other lens.

The curves of the several glasses which compose the lenses differ from the aplanatic lenses for landscapes and groups, as made by us, and in well-known and common use, and also from those well known as Dallmeyer's rectilinear lenses



NEW PHOTO-CAMERA LENSES.

(which also consist of two pairs of cemented lenses), in not being ground symmetrically and alike, but dissimilar, and in such manner that while the surfaces R^2 and R^3 have curves of equal or nearly equal radius, the radius of the surface R^4 is shorter than that of R^1, and the radius of R^5 longer than that of R. The first and fourth lenses are made of flint-glass, and the second and third of crown-glass.

The accompanying drawing illustrates the rule for determining the curves of the several lenses, and represents an apparatus of 9″ 8¼‴ (nine inches eight and a quarter lines) real focal length, in which $R=+45'''.8$; $R^1=\pm 28'''.6$; $R^2=-200'''.2$; $R^3=-200'''.2$; $R^4=\pm 23'''.1$; $R^5=+61'''.7$; $d=2'''.75$; $d^1=4'''.84$; $d^2=4'''.84$; $d^3=2''.75$; S=60.5; the indices of refraction of the glass being—

	Yellow beam.	Violet beam.
Crown	1.51518	1.52530
Flint	1.57402	1.59010

The particular size and dimensions shown in the drawing are only in illustration of our invention, which may be put in practice on a larger or smaller scale.

By our novel method of forming and arranging the lenses more pure and undistorted images are formed than by any other method, and it is applicable not only to lenses for obtaining photographic portraits, but to lenses used for other optical purposes where bright and undistorted images are required to be produced.

CAMACHO'S NEW ELECTRIC BATTERY.

THE accompanying engraving illustrates a new battery, invented by Signor Camacho, which possesses many interesting features. The ordinary bichromate of potass battery is well known as one of the most powerful in existence, and, were it not for the fact that it is also one of the most intermittent and unreliable, it would in all cases be used instead of either the

CAMACHO'S NEW ELECTRIC BATTERY.

Grove or Bunsen's battery, both of which are of a very much more expensive character in their working, and at the same time give out powerful and noxious fumes, which are entirely absent in the bichromate battery. The inventor of the new battery, M. Jose Santiago Camacho, of Paris, has for some years been experimenting with a view to overcome the defects of the bichromate battery, and the result is a singular success, for while the utmost limit of reliable working of the Grove and Bunsen batteries is from two to three hours, Camacho's arrangement will give equal results for ten, and, under special circumstances, for twenty consecutive hours.

The intermittent action of the bichromate battery is mainly due to the rapid deposition upon the surface of the carbon element of one or other of the chromic oxides or salts, which so rapidly increases the resistance as to render the battery for the time being almost powerless. Many attempts have been made to overcome this difficulty, such as shaking the solution or raising and lowering the plates, but the improvement is in each case only a temporary one, the best results being only given out for a few minutes immediately after such agitation.

The principle upon which the battery is constructed is very simple. A complete system of circulation is introduced by means of which the surface of the carbon element is kept clean. The following figures give the comparative value of the battery as compared with Bunsen's, both as regards electro-motive force and cost of working:

	Bunsen's.		Camacho's.
Electro-motive force	11.123		12.902
Interior resistance	154		.320

Cost per hour of one cell:

	Francs.		Francs.
Zinc	0.0127		0.0127
Sulphuric acid	0.0044		0.0028
Nitric acid	0.0243	Bichromate potass	0.0050
	0.0414		0.0205

It will thus be seen that the electro-motive force of Camacho's battery, and consequently the tension, is higher than Bunsen's; but as the interior resistance is at least double, it is necessary to give double the surface in each cell in order to produce the same quantity. The cost of working, it will be seen, is less than one half.

The following are the results arrived at by Messrs. Blambeck & Darkin, of Queen Victoria street, the manufacturers of the battery, in testing six cells of this battery a short time since: The battery fresh charged gave a mean internal resistance for each cell of .1667 ohms, or about one sixth of an ohm, and the tension was equal to 1.79 Daniell's. The battery was then connected to an electro-magnetic engine, which it kept in rapid action for more than eight hours. It was then disconnected, and allowed to remain charged all night, and on being again put in action next morning and tested, it was found that the tension had risen from 1.79 to 1.86 Daniell's, while the resistance remained precisely the same as it had been the previous day, or was, if any thing, a trifle lower.

The above resistance was rather higher than it should be, as the porous cells used on that occasion were not of so good a quality as M. Camacho is now producing. The battery took the gold medal at the International Exposition of Paris, 1875, and also a bronze medal from the Society of Encouragement, Paris.—*The Engineer.*

A NEW INTENSIFIER.

For Line Work.—Into a saturated solution of sulphate of copper pour a solution of bromide of potassium, enough to turn the color of the negative to a white. This may be done either by pouring off and on several times, or by leaving it in the dish till the color changes; the stronger the bromide is in the solution, the quicker will it change. When this stage is attained, wash the plate, and pour on a solution of nitrate of silver. The film will now become denser and black. If not dense enough, repeat the operations. It is rarely necessary to go further; but if any disappointment is experienced, it is a sure sign of derangement of the bath, perhaps too weak, as it is, of course, absolutely required to have enough silver on the negative to take up the bromide. For portraits and similar work it is not required to carry the intensifying to the white stage—simply pouring on the solutions alternately, and immediately washing the plate, till the required intensity is obtained, is enough.

It may be that some one may find it necessary to give still greater density, or from some cause the negative does not attain to the density it ought to, and no amount of repetitions add any thing to the density. Proceed as follows: Wash the film with a weak solution of cyanide; then pour on a solution of iodide of potassium dissolved in alcohol, with the addition of iodine. The color will change to yellow, and be very dense.

Such is the adaptability of this intensifier that almost any of the ordinary re-intensifiers may be used over it. In all cases it is of the utmost importance to commence with clean lines, and not to over-expose.—*Anthony's Bulletin.*

STANLEY'S AFRICAN DISCOVERIES.

MR. STANLEY, in the work he has already done, has made a substantial contribution to African geography, and the last letters from him which have recently appeared in the *Daily Telegraph* raise eager hopes that shortly we shall hear of his having accomplished work of even greater value.

One of the most satisfactory parts of Mr. Stanley's work is undoubtedly his circumnavigation of the Victoria Nyanza, and the filling in of its outline with something approaching to accuracy. Previous to Mr. Stanley's visit we were dependent mainly on conjecture for the configuration and dimensions of this important lake, supplemented by the observations at one or two points of Speke, on whose name Mr. Stanley's discoveries have shed additional glory. The "numerous islands" of Speke's map have many of them been visited and most of them been seen and named, and are found to extend almost all round the lake at a short distance from the shore. The names at least of many of the tribes that inhabit the shores and the islands have been obtained, and not a few details concerning their customs and physique. Stanley's account of his visits to Mtesa are in the highest degree interesting, and can not but raise our admiration of the excellent diplomacy of the determined commissioner of the *Telegraph* and the *Herald*. As to the extent of the lake, the conjecture that it is about 1000 miles in circumference is probably not far from the mark; from the observations of Stanley its height above sea-level is calculated to be 3800 feet, very near to one, at least, of the observations obtained by Speke.

Probably after the circumnavigation of the Victoria Nyanza, the most satisfactory piece of work done by Stanley has been the tracing of a large portion of the lacustrine river Kagera. Speke's Lake Windermere has been found to be only one of a series of at least seventeen lakes, which are in reality one, which are fed and drained by the river Kagera, and which Stanley with considerable reason regards as "the real parent of the Victoria Nile," and along with the Shimeeyu river on the south, the main feeder of the Victoria Nyanza. Stanley's account of his exploration of this lake-river is of such importance that we shall quote his own words:

"While exploring the Victoria lake I ascended a few miles up the Kagera, and was then struck with its great volume and depth—so much so as to rank it as the principal affluent of the Victoria lake. In coming south, and crossing it at Kitangule, I sounded it and found fourteen fathoms of water, or 84 feet deep, and 120 yards wide. This fact, added to the determined opinion of the natives that the Kagera was an arm of the Albert Nyanza, caused me to think the river worth exploring. I knew, as all do who understand any thing of African geography, that the Kagera could not be an effluent of Lake Albert, but their repeated statements to that effect caused me to suspect that such a great body of water could not be created by the drainage of Ruanda and Karagwe, and that it ought to have its source much further, or from some lake situate between Lakes Albert and Tanganyika. When I explored Lake Windermere I discovered, by sounding, that it had an average depth of 40 feet, and that it was fed and drained by the Kagera. On entering the Kagera, I stated

that it flashed on my mind that it was the real parent of the Victoria Nile; by sounding I found 52 feet of water in a river 50 yards wide. I proceeded on my voyage three days up the river, and came to another lake about 9 miles long and a mile in width, situate on the right hand of the stream. At the southern end of this lake, and after working our way through two miles of papyrus, we came to the island of Unyanyubi, a mile and a half in length. Ascending the highest point on the island, the secret of the Ingezi or Kagera was revealed. Standing in the middle of the island I perceived it was about three miles from the coast of Karagwe, and three miles from the coast of Kishakka west, so that the width of the Ingezi at this point was about six miles, and north it stretched away broader, till beyond the horizon green papyri mixed with broad grey gleams of water. I discovered, after further exploration, that the expanses of papyri floated over a depth of from 9 to 14 feet of water, that this vegetation, in fact, covered a large portion of a long shallow lake; that the river, though apparently a mere swift-flowing body of water, confined seemingly within proper banks by dense tall fields of papyri, was a current only, and that underneath the papyri it supplied a lake varying from five to fourteen miles in width, and about eighty geographical miles in length. Descending the Kagera again some five miles from Unyanyubi, the boat entered a large lake on the left side, which, when explored, proved to be thirteen geographical miles in length by eight in breadth. From its extreme western side to the mainland of Karagwe east was fourteen miles, eight of which was clear open water; the other six were covered by floating fields of papyri, large masses or islands of which drift to and fro daily. By following this lake to its southern extremity I penetrated between Ruanda and Kishakka. I attempted to land in Ruanda, but was driven back to the boat by war-cries, which the natives sounded shrill and loud. Throughout the entire length (eighty miles) the Kagera maintains almost the same volume and nearly the same width, discharging its surplus waters to the right and to the left as it flows on, feeding, by means of the underground channels, what might be called by an observer on land seventeen separate lakes, but which are in reality one, connected together underneath the fields of papyri, and by lagoon-like channels meandering tortuously enough between detached fields of this most prolific reed. The open expanses of water are called by the natives so many 'rwerus,' or lakes; the lagoons connecting them and the reed-covered water are known by the name of 'Ingezi.' What Speke has styled Lake Windermere is one of these 'rwerus,' and is nine miles in extreme length and from one to three miles in width. By boiling point I ascertained it to be at an altitude of 3760 feet above the ocean, and about 320 feet above Lake Victoria. The extreme north point of this singular lake is north by east from Uhimba, its extreme southern point. Karagwe occupies the whole of its eastern side. South-west it is bounded by Kishakka, west by Muvari, in Ruanda, north west by Mpororo, north east by Ankori. At the point where Ankori faces Karagwe the lake contracts, becomes a tumultuous noisy river, creates whirlpools, and dashes itself madly into foam and spray against opposing rocks, till it finally rolls over a wall of rock ten or twelve feet deep with a tremendous uproar—on which account the natives call it Morongo, or the Noisy Falls."

The last published letters of Stanley must be regarded as a really valuable contribution to the solution of the great Nile problem and to an accurate knowledge of Central Africa. He has proved himself an explorer of the greatest capability, and the expedition he leads reflects credit on the enterprise and public spirit of the proprietors of the two newspapers who have sent him out.—*Nature.*

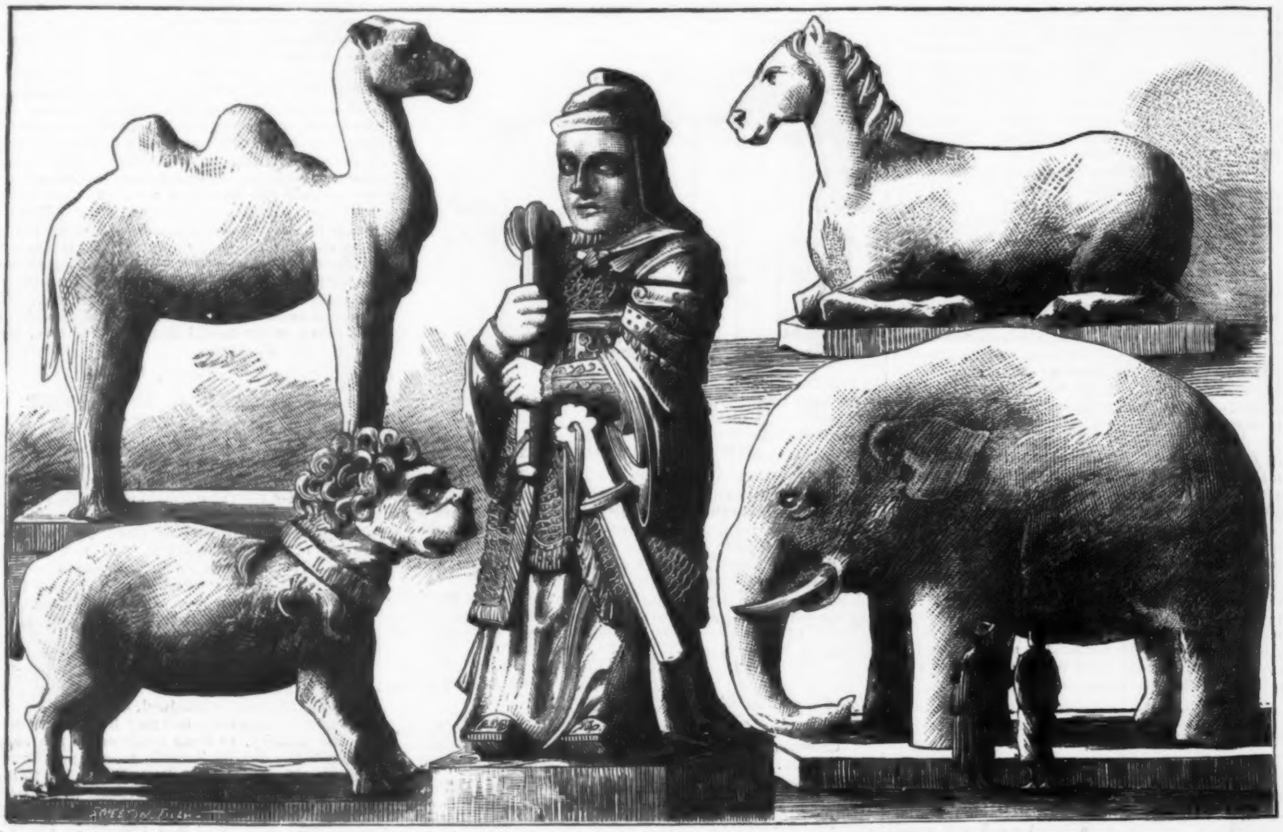
A GENERATION ON THE MARCH.

A RECENT English magazine gives the following interesting summary of statistics concerning the life and death of a generation of people:—

An English generation on the march from the cradle to the grave is an instructive spectacle. Let us trace the physical fortune which any million of us may reasonably expect. The number, to begin with, is made up of 511,745 boys and 488,255 girls, a disproportion which, by and by, will be redressed by the undue mortality of the boys, and will be reversed before the close of the strange, eventful history. More than a quarter of these children will die before they are five years old—in exact numbers, 141,387 boys and 121,795 girls. The two sexes are now nearly on a level. The next five years will be much less fatal. In the succeeding five years, from ten to fifteen, the mortality will be still further reduced. Indeed, for both sexes this is the most healthy period of life; the death-rate, however, is lower for boys than for girls. There will be some advance in deaths in the next five years and still more in the five which follow, but 634,045 will certainly enter on their twenty-sixth year. Before the next ten years are at an end, two thirds of the women will have married. The deaths during that period will be 62,052, and of these no fewer than 27,134 will be caused by consumption. Between thirty-five and forty-five, a still larger "death-toll" will be paid, and little more than half the original band—in exact numbers, 502,915—will enter on their forty-sixth year. Each succeeding decade, up to seventy-five, will now become more fatal, and the numbers will shrink terribly. At seventy-five only 161,124 will remain to be struck down, and of these 122,559 will have perished by the eighty-fifth year of their march. The 38,565 that remain will soon lay down their burdens; but 2153 of them will struggle on to be ninety-five, and 223 to be 100 years old. Finally, in the 108th year of the course, the last solitary life will flicker out. Such, then, is the average lot of a million English men and women.

COMPANIONS OF THE POLE STAR.

WHEN observing the pole star, in 1869, at Antwerp, with a 4-inch equatorial, M. de Boë detected, besides the known companion, two others much nearer and fainter. He sought a confirmation of the observation with a telescope having a silvered mirror (40 cm.), but failed; nor could P. Secchi, to whom he wrote, express certainty on the point. This year, using a 6 inch equatorial, he has again observed the comites, and the observations of Baron von Eithorn agree closely with his. He thinks it not unlikely that these companion stars are subject to a variability of brightness, or to comparatively rapid translations round the principal star.

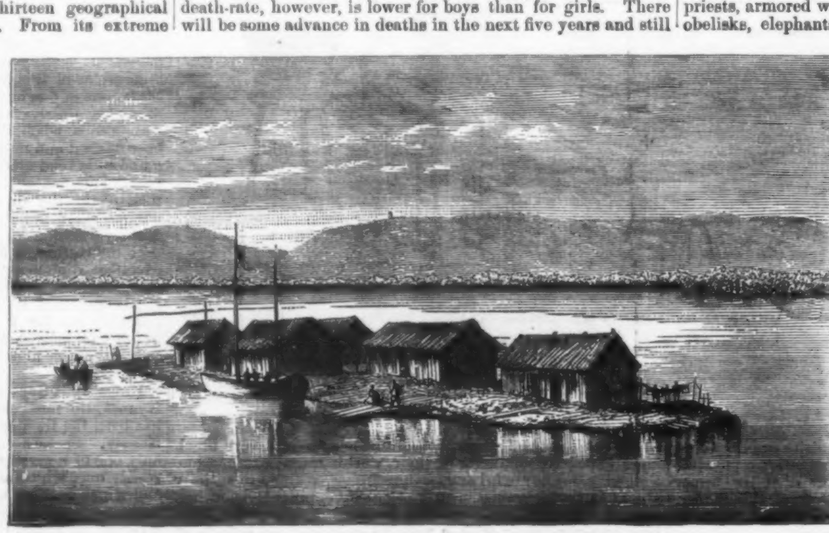


REMARKABLE ANCIENT STATUES, NEAR NANKIN, CHINA.

ANCIENT CHINESE STATUES.

THE great tomb of the Ming dynasty is located about a mile and a half from the city of Nankin, China. It consists of an artificial mountain of earth in the shape of a quadrangular pyramid, in which is said to be buried the body of the founder of the royal line. Several massive structures of stone are grouped about the mound, and three circles of earthwork surround it. At the third circle begins a road leading to the principal structure, the sides of which are lined with the colossal statues represented in our engraving. These massive works hewn from stone are arranged in pairs, and represent priests, armored warriors, horses, dogs standing and crouching, obelisks, elephants, camels, lions, and sundry curious beasts remarkable for curled hair or manes, the nature of which cannot be determined. The figures of men are about ten feet in height, those of the elephants thirteen feet. The road is about .6 of a mile in length.

The sculpture on the statues is executed with great minuteness, and even the embroideries on the garments of priests are exquisitely carved. Hence, apart from their value as works of art, the figures are of considerable archæological importance, as they exhibit the costumes and arms of the classes of ancient people represented.



CHINESE FLOATING DWELLINGS.

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THE boatmen who live on rafts on the Mississippi, and those whose habitations are permanently on the great clusters of canal boats which are constantly being towed down the Hudson River, find their parallel in the Chinese lumbermen—a class which may be literally termed the "floating population"—whose habitations are erected on the huge log rafts which navigate the rivers of China. Wood in that country, especially beside the rivers and near the sea, is a scarce commodity, and to bring the lumber to seaside cities and towns from the interior forests is a proceeding conducted with that utter disregard of haste for which the Celestials are famous. Consequently, when a large amount of wood is to be transported, the lumbermen and their families migrate with it, and the raft becomes the foundation for a floating village, containing perhaps half a dozen cottages. Hence the curious sight represented in our engraving of a number of houses drifting along with the current is by no means of unusual occurrence at Nankin and other large river cities of China. In some of the large seaports these floating houses are permanently anchored, and their owners transport soil from the land and construct artificial gardens—where vegetation flourishes—so that the raft entirely loses its identity, and a miniature island appears.